IMPACT OF
ENVIRONMENTAL, ENERGY, AND SAFETY REGULATIONS
AND OF
EMERGING MARKET FACTORS
UPON THE UNITED STATES SECTOR OF THE
NORTH AMERICAN AUTOMOTIVE INDUSTRY

U.S. DEPARTMENT OF COMMERCE
Domestic and International Business Administration

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Office of Business Research and Analysis
Bureau of Domestic Commerce
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CHAPTER I

INTRODUCTION AND SUMMARY

In his December 1974 talks in Washington, D.C. with President Ford, Prime Minister Trudeau noted the importance of the U.S. and Canadian automotive industries and suggested that joint studies, including the future of the automotive industry in North America, would be useful. Representatives of the two governments met in November 1975 and established guidelines to prepare separate but parallel studies of the impact of environmental, energy, safety regulations and emerging market factors upon the respective sectors of the North American automotive industry. This study was prepared during 1976; although in several instances data have been updated, essentially this report is current as of late 1976.

Within each country's economy the automotive industry plays a leading role as a major manufacturer and a major employer. The impact of external factors on both industries has continued to grow; in recent years the automotive industries have become increasingly subject to regulations, particulary in the design of motor vehicles to meet certain government standards. Today these standards in the United States (a) establish permissible levels of emissions from engines, (b) specify performance standards intended to make the vehicles safer for occupants and environs and (c) set a required level of fuel economy in terms of miles per gallon.

Reinforced with the authority of law the standards influence significantly what the industry will produce. Therefore, the standards become a major influence on automotive production and employment, and the ability of the industry to meet consumer demands in the market place.

In terms of scope, this study examines the U.S. sector of the North American automotive industry, including:

1. An introduction to the industry and its operation;
2. A discussion of the impact of safety, environmental and energy regulations on the automotive industry through the year 1985; and
3. Discussion of imports of parts and components from expanding automotive industries in third countries.

Although government regulations are external to the automotive industry they will be major factors influencing the industry in years to come. The state of the industry through 1985, the period under study, cannot be predicted with any certainty. The most uncertain elements in the period are the government regulations, as these regulations are subject to change--and are changing--and the continued availability of fuel. Having noted the difficulties of estimating, some generalizations concerning the probable impact of government regulations on the U.S. sector of the North American automotive industry and its products can

nevertheless be made, together with a review of the present state of the industry.

The desire and need for the personal mobility afforded by the automobile will remain relatively unchanged. The average automobile will be smaller and its price, relative to other goods, may grow higher. Employment in the U.S. automobile industry may grow at less than historic rates.

World production of vehicles will continue to increase but United States imports of cars will probably remain about 15 percent of the domestic market. Most imports of parts from overseas are for use in repair and maintenance of imported vehicles. Imports of parts for assembly may rise but will remain a relatively small portion of U.S. automobile industry production. The design distinction between North American type cars and European cars will be reduced as the U.S. automotive industry moves toward smaller cars and more cars of common design are produced in different countries.

The automobile will remain the primary means of personal transportation through 1985. The motor vehicle industry contributes about 2 percent of the total GNP and 14 percent of the national income generated by durable goods. Factory shipments of passenger cars and trucks totaled $41 billion in 1975. Annual employment

in the U.S. motor vehicle industry from 1970 to 1975 ranged from a high of 955,000 in 1973 to a low of 774,000 in 1975. Average hourly earnings are about two-fifths higher than the average for production workers in all industries. The four major motor vehicle companies purchase about 44 percent of their parts and components from independent suppliers.

Federal and local governments are giving increasing attention to the influence of motor vehicles on the welfare of people and the environment. Elimination of environmental pollution, conservation of petroleum--of which vehicles are an important consumer--and requirements for vehicles of safer design are being mandated by various regulations. Unfortunately these regulations sometime have conflicting consequences. For example, designs for safer vehicles sometimes increase vehicle weight which in turn increases fuel consumption. The technology available for engine emission control can also increase fuel consumption. Some observers believe there is a need for coordination of regulation of the automobile to achieve a better balance of costs and benefits to society.

The goal of a safer, less polluting and more fuel-efficient automobile is being sought through re-design of existing components, creation of new types of power plants and introduction of new materials into vehicle construction. New types of engines are under development but are not yet capable of replacing the present day internal combustion

4-cycle gasoline engine in terms of reliability and cost. Additionally, if a completely new engine were adopted, 12 to 15 years of lead-time would be necessary to build enough new production and assembly lines to supply the millions of engines needed each year.

New technology is seldom introduced across-the-board in a single model year in the automobile industry. This is true, in part, because of lead-time requirements. Capital needs also may play a part, but one of the most important reasons is the commercial risk involved in putting millions of warrantable items into consumer service without adequate experience. Many materials are being investigated in an effort to produce lighter-weight and hence more efficient cars. As much as 1,000 pounds have been removed from the weight of some larger size 1977 models. To assist in the continuing effort to reduce car weight additional research is expected to increase the use of such materials as aluminum, plastics and high strength low alloy steels.

Petroleum is a natural resource available in a finite quantity. Though the total quantity of petroleum available is not precisely known, it seems clear that with a growing rate of consumption the world supply of oil will likely become increasingly scarce and gasoline prices must inevitably rise well above their present relative price levels. The growing petroleum shortage and government requirements for

fuel conservation will force the production of smaller, lighter cars and override the desire of many customers for larger vehicles. Most estimates are that the regulations concerning engine emission and fuel consumption will cause future vehicles to average no larger than current sub-compacts in weight.

U.S. consumption of gasoline and fuel oils is continuing to increase but development of new U.S. sources or expansion of existing sources is not keeping pace, thus accentuating U.S. dependence on foreign source petroleum. Many different liquids are being evaluated as possible replacements for the fuels currently used. Additional technical effort and substantial additional funding might result in successful derivation of synthetic fuel for vehicles using coal and/or shale oil as the source but estimated quantities of fuel available from these sources are no more than a small fraction of projected future consumption.

The American people are expected to continue to demand the personal transportation provided by the privately-owned auto. The most significant influences in the level of demand are growth of the driving age population and the level of disposable income. Intermediate, short term influences are also present, such as the fuel shortage created by the petroleum embargo. For the long term, the driving age population will continue to grow (albeit at a slower rate

than previously) and disposable income will continue to increase. The proportion of households owning two or more cars will grow. The annual sales rate of automobiles is projected at about 13 million in 1985, assuming customer acceptance of the smaller cars.

The expansion of mass transit systems is expected to have little effect on the number of new cars sold.

The laws and regulations presently scheduled for safety, damageability, emissions and fuel economy will require additional capital expenditures by the four domestic producers, variously estimated at $15 billion by the Automobile Industry Task Force in its July 1976 report to the Committee on Banking, Currency, and Housing, House of Representatives, and between $5 and $10 billion for equipment and special tooling over the next decade by the Federal Task Force on Motor Vehicle Goals Beyond 1980 in its draft report of September 2, 1976. The increase in demand for capital invokes the question of the industry's capability to raise capital of this magnitude.

The Federal Task Force on Motor Vehicle Goals Beyond 1980 concluded its draft report on September 2, 1976, to the Energy Resources Council with a list of some of the important risks and issues. While the risks are clear, the issues involve questions that identify difficult problems for the future as outlined below from the Task Force report:

Risks.

1. The consumer may not buy the lighter cars in percentages which would yield the "mandated" fleet economies. Fines on the manufacturers will not necessarily solve this problem. Alternatively, low consumer acceptance of models offered will result in low total sales. Industry investment, and overall economic posture, would be jeopardized.

2. Inability to react to such uncertainties can create especially serious problems for smaller manufacturers who are less able to put up development funds and to risk major capital on new directions.

3. Changes in the national economy which have historically demonstrated overpowering effect on consumer buying power and habits cannot be ruled out.

4. Consumer "behavioral" patterns are shifting and are hard to predict. These changes have a real effect on acceptance of lighter cars.

5. Potential changes in regulations on safety, emissions and fuel economy create further uncertainties. The same is true with respect to wholly new regulations which may be introduced (e.g. sulfates).

6. Unforeseen changes in technology which are not now clear could alter the development path.

Issues.

1. How can the American public be convinced of the need for changeover to more fuel-efficient motor vehicles, and be induced to accept the types of automobiles which will achieve desirable fuel economy? Without public acceptance and purchases, the most fuel-efficient design is useless. The mandated 27.5 mpg fleet fuel consumption standard in 1985, for example, appears to be technologically feasible, but can only be realized with public cooperation and full understanding of the purpose. This issue looms as the major dilemma facing the Federal Government and the industry.

2. How rapidly can industry change over to more fuel-efficient automobiles without undue burden or impact on itself, its suppliers or on levels of employment? Ideally, any changeover should take place gradually, with adequate advance knowledge and with maximum flexibility for each segment of the industry.

3. How should the nation handle the risk which the automotive industry must accept in motor vehicle changeover to fuel-efficient models? The impact of these risks is especially important in the light of the many uncertainties which underlie such changeovers.

4. How can the considerable risks associated with changeover be reduced for the smaller companies?

5. How may the Federal Government effectively balance the sometimes conflicting objectives of reduced energy, increased safety, and improved environmental quality in the requirements it imposes on the automotive manufacturers and their products, especially when these requirements are imposed by several independent agencies with separate authorities?

6. How far should passenger safety and emissions control be mandated into automobile designs? At what point do incremental costs outweight incremental gains?

7. What changes should be made in Federal policies and regulations to provide effective incentives for automobile manufacturers to more rapidly develop and supply automotive technology having substantial public benefits?

The question of customer acceptance of the new generation of smaller size vehicles has been raised. Should a substantial segment of the market elect to defer purchasing new cars, the effect on the industry and the national economy could be severe for a time. In addition, the technology--particularly for

controlling automotive emissions--is uncertain at this time. As an example, the vehicle manufacturers state they are not able to meet statutory emission standards by the 1978 model year and are, therefore, requesting legislative relief.

CHAPTER II

ROLE OF THE MOTOR VEHICLE IN U.S. TRANSPORTATION

In U.S. transportation, the motor vehicle dominates in the movement of people and plays a major role in the movement of goods. Most people make most of their travel trips in motor vehicles. Nearly all goods that reach consumers go at least part of the way by motor vehicle.

People. Two sets of recent official data show how people in the United States travel:

The Nationwide Personal Transportation Study of 1969-70 was conducted by the U.S. Bureau of the Census for the Federal Highway Administration.[1/]

The National Travel Survey of the 1972 Census of Transportation.[2/] The first covers all person-trips, one way, by private motor vehicle or public transport, by persons five years old and over. The second covers only round trips of 200 miles or more but excludes: (1) travel as part of an

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1/ The results were published in several volumes. Report No. 9, November 1973, contains data on mode of transportation and characteristics of tripmakers.

2/ U.S. Bureau of the Census, Census of Transportation, 1972, Volume 1, National Travel Survey, U.S. Government Printing Office, Washington, D.C. 1973.

operating crew of a train, plane, bus, truck or ship; (2) commuting to place of work; and (3) student trips to school or those taken while in school.

All Trips. The 1969-1970 study found that persons five years old and over in the U.S. made more than 145 billion trips, nearly 99 percent of them in motor vehicles. The survey revealed 85.1 percent were made in automobiles, 7.6 percent in buses, 5.6 percent in trucks, and 0.5 percent by taxi and motorcycle. See Table 2-1, Appendix for more detail.

Trips 200 Miles and More. In 1972, persons in the U.S. made 458 million round trips of at least 100 miles each way. Eighty-seven percent of the trips were made in motor vehicles, including 85.2 percent by automobile and truck and 1.8 percent by bus.

Person-Trips by Means of Transport, 1972

Means of Transport	Person-Trips 1/ Number (000)	Percent of Total
Auto/Truck	390,674	85.2
Bus	8,413	1.8
Train	1,880	0.4
Air	53,891	11.8
Other	3,626	0.8
Total	458,484	100.0

1/ At least 100 miles away from home and return.

Source: U.S. Bureau of the Census, 1972 Census of Transportation, National Travel Survey.

Intercity. Table 2-2 shows data on intercity travel by mode for 1960 and each of the years 1965-1973. As with total trips and trips 200 miles and over, motor vehicles accounted for a much greater proportion of total intercity passenger miles than did all other modes combined. In more recent years, however, motor vehicles and railroads carried slightly smaller shares than in the earlier years, while the airlines share of the total grew and the inland waterway share remained unchanged.

Rural vs. Urban. Data are not available to provide a clear breakdown between travel which takes place within rural areas and that which takes place within urban areas. We know from observation that in most, if not all, parts of the United States a high proportion of travel is by motor vehicle within both rural areas and urban areas, however defined, but we do not have data to show precisely what this proportion is.

The nationwide Personal Transportation Study collected data for travel by motor vehicle broken down between trip-makers living in incorporated places and those living in unincorporated areas.[3/] Incorporated places ranged in size from 5,000 to a million or more persons, but according to Report No. 9, "Although unincorporated areas are predominantly

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3/ op. cit., Report No. 9, November 1973, Tables J, K, L and M, pp. 19, 20, 21, 22.

rural in the country at large, they cannot be equated with 'rural areas', because they include many densely populated areas as in the urban towns of New England, urban townships in New Jersey and Pennsylvania, and urban counties around the country."

The data in Report No. 9 show that 99 percent of the trips by residents of incorporated places and 100 percent by those of unincorporated areas were by motor vehicle, including private automobiles, trucks, school and public buses and taxicabs.

The following table gives data from the 1972 Census of Transportation on trips 200 miles and over by area of residence and percent by motor vehicle. Persons living in Standard Metropolitan Statistical Areas (SMSA) made about the same percent (84) of their trips by motor vehicle whether they lived in or outside the central city. Persons not living within SMSA's, on the other hand, made a much higher proportion, 93 percent, of their trips by motor vehicle.

Person-Trips by Area of Permanent Residence and Percent by Motor Vehicle, 1972

Area of Residence	Person-trips[1/] Number (000)	Percent by Motor Vehicle[2/]
In SMSA[3/] - Central City	77,251	83.7
In SMSA - Outside Central City	228,638	84.1
Not in SMSA	152,595	93.1
Total	458,484	87.0[4/]

1/ At least 100 miles away from home and return.
2/ Automobile, bus and truck.
3/ Standard Metropolitan Statistical Area.
4/ Weighted average of three categories.

Source: U.S. Bureau of the Census
Census of Transportation, 1972, Vol. I
National Travel Survey

Goods. Motor vehicles, mainly trucks, play a significant role in the movement of intercity freight within the United States. While available data are not adequate to measure precisely the role of motor vehicles within most U.S. cities or urban areas, observation shows clearly that the role is a dominant one within most cities, large and small.

Except for the World War II years and two others, 1951 and 1955, trucks gained a larger share of total intercity freight each year from 1939 to 1958 when the share reached 21.1 percent. Since that year, the share has remained fairly constant, fluctuating narrowly between 21 and 23 percent.

Trucks play a much greater role in the intercity movement of manufactured goods. According to the 1972 Census of Transportation, trucks, for hire and private, hauled 57 percent of the intercity tons and 37.2 percent of the ton/miles. These shares were up from 51.1 percent of the tons and 31.2 percent of the ton/miles in the 1967 Census of Transportation.4/

<u>An Automobile - Oriented Transportation System</u>. The U.S. has, and probably will continue to have an automobile-oriented transportation system. While the use of private automobiles has provided social and economic benefits, it has not been without costs.

The automobile offers personal freedom of movement, efficient use of time, and other conveniences of personal transportation demanded by the public.

The automobile allows people to live at remote locations with respect to places of employment, shopping areas, etc. The growth in the size and population of suburban areas results in higher employment in service industries, housing construction industry, etc., and allows for economic expansion of these communities.

Automobile travel has created a need for highway services such as highway restaurants, travel motels, and stimulated

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4/ U.S. Bureau of the Census, Census of Transportation, 1972, Commodity Transportation Survey - Area Series, Area Report & United States Summary, 1975, p. 8-1.

the growth of vacation and recreation areas. The automotive and related industries employ hundreds of thousands of workers, resulting in the improvement of the quality of lives of individuals, communities, and growth of the national economy in general.

On the other hand, a large number of people are killed or injured in auto accidents, and the automobile is instrumental in causing a substantial amount of property damage.

The automobile is an important polluter in urban areas, having significant adverse impact on the air quality in our cities. However, it should be noted that while motor vehicle exhausts are responsible for 40 to 45 percent (by tonnage) of air pollution on a national basis, they are responsible for only about 15 percent on a health effect basis.[5/]

The motor vehicle sector is, of course, a consumer of about 20 percent of energy in this country.

Motor vehicle travel increases the demand for highways, which in turn causes land-use problems, relocating neighborhoods, and environmental deterioration associated with highway construction. However well planned and efficiently generated public transportation systems may have similar adverse effects.

5/ For example, sulfur oxides are highly toxic but are not part of auto exhaust emission.

The automobile encourages people to move away from the congestion, crime and pollution of central cities. At the same time it opens distant recreational facilities to central city residents.

CHAPTER III

ROLE OF MOTOR VEHICLE INDUSTRY IN THE ECONOMY

The motor vehicle and equipment industry contributes about 2 percent of the total Gross National Product (GNP) and about 14 percent of the national income generated by durable goods. Purchases of motor vehicles and parts are a major component of consumer spending and amounted to $53 billion in 1975.

From 1950 to 1975, personal consumption expenditures (PCE) for motor vehicles as a percent of total PCE ranged from 6.9 percent in 1972 to 5.1 percent in 1975. The average for the 15-year period was 6 percent.

Employment and Other Labor Aspects. The motor vehicle and equipment industry (SIC 371) employed 774,000 workers in 1975, making it the largest manufacturing industry in the United States in terms of employment. Although motor vehicle manufacturing accounted for only 1 percent of total nonagricultural employment, it accounted for 4.2 percent of manufacturing employment and 7.2 percent of employment in the durable goods sector of manufacturing.[1/]

1/ Table 3-1, Appendix.

Motor vehicle manufacturing is subject to cyclical behavior. During the 1965-75 period, total employment in this industry fluctuated between 774,000 and 955,000 (see employment table below), reflecting the cyclical pattern of motor vehicle production and the sensitivity of the industry to changes in consumer preferences, the availability of credit, defense activity, oil prices and the level of economic activity.

Total Employment and Production-Worker Employment in Motor Vehicle Manufacturing, 1965-75

	Total employment (000's)	Production worker employment (000's)	Production worker employment as percent of total employment
1965	842.7	658.9	78
1966	861.6	670.3	78
1967	815.8	626.9	77
1968	873.7	680.8	78
1969	911.4	708.0	78
1970	797.3	604.2	76
1971	842.6	651.3	77
1972	862.8	668.6	77
1973	955.3	743.4	78
1974	890.8	682.3	77
1975	774.1	593.4	77

Source: Bureau of Labor Statistics, survey of payroll employment in nonagricultural establishments as reported in Employment and Earnings.

Further illustrating the volatility of employment within the industry is the fact that both the high and low employment years for the period occurred within the last three

years. Following record employment of 955,000 in 1973, employment dropped to 774,000 in 1975, the lowest level since 1964. This precipitous drop appears to have been caused by two major factors. First, the economy of the United States was going through a period of contraction at this time. Similar occurrences had caused employment declines in the past, notably 1970. However, in addition to the 1975 contraction, the Arab oil embargo, which began in late 1973, created a mood of uncertainty among consumers regarding the future supply and price of gasoline. Consequently, sales of full-sized automobiles suffered a particularly severe decline.

The recent economic upturn coupled with improved fuel economy in new American cars and dissipation of the fear of a gasoline crisis provided a good year for the motor vehicle industry in 1976. The industry's employment averaged 851,000 in 1976, up 9.9 percent from the 1975 level of 774,000.

Earnings. In 1975, earnings of production workers in motor vehicle manufacturing averaged $6.47 hourly, more than two-fifths higher than the average for production workers in all industries, more than one-third higher than the average for those employed in all manufacturing industries, and about one-fourth higher than the average for those employed in all durable goods manufacturing industries.

Hourly earnings of production workers in the motor vehicle manufacturing industry rose in each year of the 1965-75 period, with the bulk of the rise occurring over the last five years. The industry's production workers received several wage adjustments under terms of collective bargaining agreements negotiated in fall 1973. Two deferred wage adjustments of about 3 percent each were granted, one in September 1974 and another in September 1975. These adjustments, however, were far exceeded by quarterly cents-per-hour increases, triggered by cost-of-living adjustment (COLA) clauses in the industry's bargaining agreements. Uniform cents-per-hour adjustment for production workers under COLA clauses has undoubtedly compressed occupational wage relationships in the industry. Earnings for production workers in motor vehicle manufacturing rose about 9 percent more during the 1965-75 period than earnings in both manufacturing as a whole and durable goods manufacturing.

While the trend throughout the period in average hourly earnings was upward, average weekly earnings fluctuated somewhat due to variations in average weekly hours (see Table 3-2, Appendix). However, the overall trend in average weekly earnings was still upward.

Production workers in U.S. motor vehicle manufacturing are also provided a wide variety of supplementary wage benefits. Benefits include paid holidays, paid vacations,

health insurance, pension plans, and supplemental unemployment payments. Details of the benefits provided over the period from 1941 to September 1976 can be found in the wage chronology for the Ford Motor Company covered by the Bureau of Labor Statistics Bulletin 1787 (dated 1973), and the Supplement to Bulletin 1787 published April 1975.

Occupational wage relationships in the industry have varied since 1950, based on Bureau of Labor Statistics survey data. Table 3-3, Appendix, shows that wage relationships by skill level narrowed considerably between 1969 and 1973.

Changing Skill Levels. Employment of production workers[2/] as a proportion of total employment in motor vehicle manufacturing has remained fairly steady over the last 10 years at about three-fourths of total industry employment. Even changes in production have failed to show significant shifts in the ratio of production workers to total employment.

The structure of occupational employment, however, has shown more change than that for production workers. As may be seen in Table 3-4, Appendix, the ratios for three of the

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2/ Production and related workers include working supervisors and all nonsupervisory workers (including group leaders and trainees) engaged in fabrication, processing, assembling, inspection, receiving, storage, handling, packing, warehousing, shipping, maintenance, repair, janitorial and guard services, product development, auxiliary production for plants' own use (e.g., power plant), and record keeping and other services closely associated with the above production operations.

four major white collar occupational groups--professional, technical and kindred; managers and officials; and sales-workers--increased over the 1960-74 period while the ratio for clerical workers remained about the same. On the other hand, the ratio for workers in blue collar occupations declined. This decline is especially apparent for craft-workers whose ratio declined from 22.74 in 1960 to 19.61 in 1974.

Productivity[3/] - Trends in the Motor Vehicle Industry 1965-74. Output per employee hour in the motor vehicle and equipment industry grew at a rate of 2.9 percent per year from 1965 to 1974, the latest year for which data are available. This rate is above the average growth rate of 2.1 percent for all manufacturing industries during the same period. However, it is significantly below the motor vehicle industry's productivity growth rate of 5.2 percent during the earlier period measured--1957 to 1964.

Within the 1965-1974 period there were significant year to year fluctuations in productivity. Gains were recorded in each of the years from 1965 through 1968. As the economy moved into the recession in 1969 and 1970, coupled with a strike in the industry in 1970, productivity in motor vehicle manufacturing posted declines of 1.7 and 4.2 percent. The industry rebounded in 1971, with a gain in productivity of

3/ Productivity is defined as output per employee hour.

16.7 percent reflecting an output increase of 25.5 percent and an increase in employee-hours of only 7.6 percent. Productivity growth continued through 1973 despite the petroleum shortage in the latter part of that year which resulted in a sharp drop in motor vehicle production in the fourth quarter. However, in 1974 as the economy slackened, productivity in the industry again dropped--declining 4.4 percent. Preliminary data indicate that in 1975 productivity increased, despite a continued drop in the production of motor vehicles, as employee-hours declined more sharply than output.

Fluctuations in the output of motor vehicles have been one of the major determinants of the short term productivity changes in this industry during the 1965-74 period. With the exception of 1967, in every year when there was a decline in output there was a corresponding decline in productivity. In 1967, productivity has a much lower than average gain of only 0.5 percent. On the other hand, with the exception of 1973, in every year that there was a large increase in output --10 percent or more--there was an above average gain in productivity. Demand for motor vehicles is highly sensitive to the business cycle, therefore, cyclical changes have had a substantial impact upon productivity in this industry.

Another factor affecting productivity movements during the 1965-74 period was the impact of two major labor disputes.

In 1967, 160,000 employees were on strike for 7 weeks, while in 1970, 400,000 employees were on strike for about two months, with some workers out for longer periods. In both of these years production registered large declines and productivity changes were poor or negative.

The rapid changeover to the production of a greater proportion of smaller size automobiles, beginning with the energy crisis of late 1973, had a significant impact on the industry's manufacturing operations. At great expense, production facilities were quickly modified to accommodate smaller automobiles, with a resulting negative short term impact on productivity. Though one assembly plant in a crash effort achieved complete changeover from production of a full sized to a compact automobile in 51 days (by crews working around the clock, 7 days a week) at a reported cost of $75 million, typically such a changeover, including procurement lead time, would take 24 to 28 months.

While cyclical movements over the 1965-74 period tended to dominate productivity changes, the key factor underlying the industry's above average rate of productivity gain has been technological change. By 1965, most phases of the industry's production operations were already highly advanced. Technological change in the post-1965 period tended to be evolutionary in scope.

Computerized techniques for motor vehicle design have become more widespread since 1965. Equipment such as graphic display terminals connected to computers, automatic drafting machines, numerically controlled machine tools, as well as advanced techniques such as computer simulations, have significantly speeded up design and engineering operations. These techniques have become particularly important in the more recent period, when shifts in demand have resulted in the rapid introduction of new model automobiles.

During the 1965-74 period the industry improved its already highly automatic transfer lines, which move parts in process mechanically from operation to operation. The more widespread use of multipurpose machines, interchangeable machine modules, storage banks for semi-finished parts, and the growth in the number of automatic operations have increased productivity in the manufacture of such components as engines, automatic transmissions and other mechanical parts.

The recent emphasis on weight savings has accelerated the use of new materials for motor vehicle manufacture. Plastics and aluminum have grown in use, providing weight savings and fewer processing operations. Complex shapes, usually body parts, are now molded from plastics reducing both manufacturing and final assembly time. Complicated

metal shapes are being fabricated from powdered metals resulting in fewer machining operations.

New paint compositions allow for "wet on wet" painting operations, which are in use in a number of plants. This technique allows the application of successive coats of paint before the previous coat has dried, speeding up painting operations.

While final assembly remains the most labor-intensive manufacturing operation, a number of new automative assembly techniques are in use, such as automatic bolt tightening and automatic robot-controlled welding.

Advanced quality control techniques are in more widespread use. Computerized testing equipment, for example, is used to inspect components, including complete automobiles engines.

Price Trends. Labor, material, and overhead costs in the automotive products industry all rose during the 1970-75 period and automobile prices rose as a result. In addition to factory cost increases, the price of motor vehicles rose due to inclusion of Government-mandated additional equipment relating to emission control and safety. The wholesale price index for automobiles rose an average of 4.7 percent per year from 1970 to 1975, compared to an average increase of 6 percent in the wholesale price index for all manufactured

goods. The consumer price index for automobiles for the 1970-1975 period rose an average of 3.7 percent per year or somewhat less than the comparable wholesale price index while the consumer price index for all items rose an average of 6.8 percent. (see the following table.)

Wholesale Price Indexes Automobiles, and Total Manufacturer and Consumer Price Indexes, New Passenger Cars and All Consumer Items 1970-75

(1967 = 100)

	WHOLESALE PRICE INDEXES		CONSUMER PRICE INDEXES	
	Passenger Cars	Total Manufacturers	New Passenger Cars	All Consumer Items
1970	106.6	110.2	107.6	116.3
1971	112.2	113.8	112.0	121.3
1972	114.9	117.9	111.0	125.3
1973	115.4	129.2	111.7	133.1
1974	123.1	154.1	117.5	143.7
1975	132.2	171.1	127.6	161.2

Source: U.S. Department of Labor

All price increases for cars are not reflected in the consumer index because increases in car costs related to increases in car quality are not included. The estimated average price paid by a final purchaser for an automobile in 1975 was $5,100[4/], an increase of 38 percent over 1970.

4/ Estimates, prepared quarterly by the Commerce Department's Bureau of Economic Analysis for use in estimating consumer expenditures for automobiles. The price includes estimates of current dealer discount from list prices, sales taxes, dealer preparation charges, and is constructed by using Wards Reports table of optional equipment, the number and mix of cars sold by nameplate sales taxes and dealer preparation charges.

CHAPTER IV

STRUCTURE OF THE MOTOR VEHICLE INDUSTRY

The motor vehicle and equipment industry, the largest U.S. manufacturing industry, is composed of many sectors. This chapter describes the current sectors of vehicle manufacturing, material and component sourcing, distribution, aftermarket servicing and other elements of structure including the Agreement Concerning Automotive Products Between the Government of the United States and the Government of Canada. In addition to manufacturing and assembling autos, the industry includes truck, truck trailer, and bus assembly, and a very substantial components and parts manufacturing element. Also there is an extensive components and parts distribution system to provide for the requirements of the aftermarket and a large number of service facilities and service mechanics to repair and maintain the vehicles after they have been put into service.

Motor vehicle manufacturing plants are located in 29 states. In 1975 the motor vehicle and equipment industry employed 774,000 persons. An additional number of employees in other industries producing automotive products is estimated at 400,000, or more

than 50 percent of the number classified in the automotive industry. Estimates show a 1972 total of 1.3 million employees in the industry, comprised of 806,000 employees in the motor vehicle and parts industry, 121,000 in the automotive stamping industry, 400,000 producing automotive products in non-automotive industries.

There are few motor vehicle manufacturers (assemblers) and many thousands of parts producers. The vehicle manufacturers produce many of the parts and components which comprise the vehicle, but purchase from independent suppliers about 44 percent of the total value of parts and components used in manufacturing. Both vehicle manufacturers and major independent suppliers have plants in Canada and the two national segments of the industry are virtually integrated in operation. The trade flow between the two countries in 1975 amounted to over $13 billion.

The automobile in 1976 is in a state of evolution that began centuries ago. The first self-propelled land vehicle is reported to have been in operation in 1769, a steam-powered military vehicle. During the period 1864 to 1885, the internal combustion engine was developed by Eugene Longen and Nikolaus Otto and was being installed in carriages built by Gottlief Daimler, Karl Benz, Wilhelm Maybach and Emile Levassor.

Although the initial development of the automobile occurred in Europe, American entrepreneurs and inventors became involved in the emerging industry in the early 1890's and took over its leadership, particularly from the standpoint of mass production and widespread distribution. In 1900 there were 8,000 automobiles on the road and now there are over 100 million registered in the U. S. alone. Since 1900 there have been over 3,000 makes of cars, countless styles and configurations, produced by 1,500 manufacturers in the U. S.[1/]

Principal Automotive Manufacturers

The General Motors Company was formed in 1908 and included Buick Motor Company and the Olds Motor Works. Oakland Motor Car Company, later known as Pontiac, Cadillac Motor Car Company and Chevrolet Motor Company were added later. These five companies have evolved into the present five car divisions of General Motors.

Henry Ford launched the Ford Motor Company in 1903 and 1,700 cars were built in the first 15 months of operation. In 1908, the famous Model T was introduced and Lincoln Motor Company was acquired by Ford in 1922. The Mercury line was introduced by the company in 1938.

1/ "Automobiles of America", Motor Vehicle Manufacturers Association, 1974.

The Chrysler Corporation, formed in 1925, was originally the Maxwell-Chalmers Corporation. In 1928 Chrysler bought Dodge and the same year introduced its Plymouth line.

The newest of the "big four", American Motors Corporation, came into being in 1954 through the merger of Nash-Kelvinator Corporation and Hudson Motor Car Company.

The four principal automobile manufacturers are also very prominent in the truck manufacturing segment of the automotive industry. Other influential truck manufacturers include: International Harvester whose primary business is manufacturing farm machinery and construction equipment; Mack Trucks, Inc., a part of the Signal Companies; White Motor Corporation; Freightliner, the truck manufacturing facility of Consolidated Freightways; and Paccar's two subsidiaries, Kenworth and Peterbilt. Other smaller companies confine their production to highly specialized configurations.

In 1975 the U. S. registration of new autos reached 6,912,511, of which 52.3 percent were General Motors products, 28.3 percent were Ford, 14.8 percent Chrysler, 4.4 percent American Motors, and .2 percent Checker Motors and others.[2]

2/ Wards Automotive Reports, February 23, 1976.

Classes of Automobiles

Various organizations have attempted to identify "Classes" or groups of cars, but there is no universal system of classification. Ward's Reports, an authoritative trade journal, for example recognizes four domestic classes: full size, intermediate size, compact size and subcompact size.

Using Ward's classifications the 1977 model year U. S. car-line breakdown is shown below:

Subcompact

American Motors	(Regular) Gremlin
Chrysler	None
Ford	(Regular) Pinto, Bobcat; (Specialty) Mustang II
General Motors	(Regular) Chevette, Vega, Astre; (Specialty) Monza, Corvette, Sundbird, Starfire, Skyhawk

Compact

American Motors	(Regular) Hornet; (Specialty) Pacer
Chrysler	(Regular) Volare, Aspen
Ford	(Regular) Maverick, Comet; (Specialty) Granada, Monarch
General Motors	(Regular) Nova, Ventura, Omega, Skylark; (Specialty) Camaro,Firebird

Intermediate

American Motors	(Regular) Matador
Chrysler	(Regular) Fury, Monaco; (Specialty) Cordoba, Charger S.E.
Ford	(Regular) LTD II, Cougar; (Specialty) Thunderbird
General Motors	(Regular) Chevelle, LeMans, Cutless, Century; (Specialty) Monte Carlo, Grand Prix, Seville

Full Size

American Motors	None
Chrysler	(Standard) Gran Fury; (Medium) Chrysler, Royal Monaco
Ford	(Standard) LTD; (Medium) Marquis; (Luxury) Lincoln; (Luxury Specialty) Mark V
General Motors	(Standard) Chevrolet; (Medium) Pontiac, Oldsmobile, Buick; (Luxury) Cadillac; (Medium Specialty) Toronado, Riviera; (Luxury Specialty) Eldorado

Plant Location and Production

The major segments of the motor vehicle industry are automobiles, truck and bus chassis, truck and bus bodies, truck (tractor) trailers, and parts and components. Automobiles are the largest segment with 1975 product shipments estimated at $28.9 billion; truck shipments accounted for an additional $11.9 billion. The motor vehicle assembly segment of the industry employed 323,000 persons, or 41.7 percent of the 774,000 employed by the industry as a whole. The Motor Vehicle Manufacturers Association reports that there were 102 auto assembly plants operating in 87 cities in 29 states in 1975.

The automotive industry also includes the component and parts manufacturers. Some of these are divisions or subsidiaries of the automobile assemblers, but many are independent suppliers to the industry.

Principal products of this parts and components group are engines, transmission systems including transmissions, clutches, transfer assemblies, propeller shafts, universal joints, final drive assemblies, differentials, and drive axles; electrical systems including alternators and starters; chassis including frame, brakes, wheels, suspension and steering; bodies including major body panels and body stampings.

In 1972 there were 3,826 motor vehicle and vehicle equipment manufacturing establishments and literally thousands of plants of smaller parts suppliers.

Table 4-1 of the Appendix lists the 1975 calendar year production of cars, trucks and buses as compiled by the Motor Vehicle Manufacturers Association. In summary, the table shows that American Motors produced 323,796 cars, Chrysler 902,902, Ford 1,808,038 and General Motors 3,679,110, for a total of 6,717,177 cars. Truck and bus production totaled 2,272,008 - in all - 8,989,185 motor vehicles.

General Motors is comprised of 26 motor vehicle industry divisions including seven vehicle manufacturing and assembly divisions,[3/] one assembly division,

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3/ There appears to be no positive definition identifying manufacturing versus assembling operations in this industry. The terms are frequently used interchangeably.

sixteen auto component manufacturing divisions, and two parts distribution divisions.

Ford, through one assembly division, assembles its cars and trucks in 18 plants, at 16 different locations. Ford, like GM, also manufactures many of the components of its cars.

Chrysler's assembly is accomplished in eight plants. Its component manufacturing facilities are located in 34 locations.

American Motors operates two commercial automobile plants and makes its own engines, bodies and body parts and certain parts peculiar to its cars.

Trucks. Automobile manufacturers also manufacture trucks. In addition, trucks are produced by a number of other companies. The following chart provides truck and bus production volume in 1975 by make.[4/]

4/ 1975 Motor Truck Facts, Motor Vehicle Manufacturers Association. Car manufacturers noted in parentheses.

Make of Truck or Bus	Units
Chevrolet (GM)	772,236
General Motors Coach (GM)	197,034
Diamond Reo	543
Dodge (Chrysler)	319,694
Ford (Ford)	692,200
International Harvester	101,872
Jeep Corporation (AMC)	139,906
Mack	24,629
White	11,793
Others	11,101
TOTAL	2,272,008

The major portion of production is by the four companies also producing cars.

Almost 90 percent of truck production is in the pickup, van and utility category, that is, 10,000 pounds or less, gross vehicle weight, and in this category various mechanical and electrical components are frequently interchangeable with passenger cars.

Of the truck manufacturers who are independent of the four principal automobile manufacturers, International Harvester has the largest volume. The "Jeep"

is produced by American Motors Corporation which also produces other commercial vehicles including buses, delivery vehicles and trucks. Mack Trucks, Inc., Freightliner, Paccar, Inc., and White Motors Corporation manufacture heavy duty trucks.

Factors in Industry Sourcing

The Big Four automobile manufacturers produce about 56 percent (by value) of the parts and components of their vehicles. Nevertheless, it is estimated that there are about 50,000 independent suppliers to the motor vehicle industry. Many of these producers are not classified as automotive producers because half or more of their total production is other than automotive. It is estimated that about 400,000 people are employed in non-automotive industries producing about $16 billion worth of parts (original equipment and replacement)[5/].

Although the large motor vehicle companies may choose to make parts and components for their own vehicles, the companies frequently find it advantageous, based on technological and economic considerations, to purchase parts and components from independent suppliers.

5/ 1975 Automobile Facts and Figures, MVMA. These figures should not be confused with the totals for dollar production and employment of the entire parts and component industry.

Available data indicate a stable[6] pattern for sourcing parts between the vehicle manufacturer's own facilities and independent suppliers. Table 4-2 of the Appendix identifies the production of original equipment parts by type of producer (i.e., motor vehicle manufacturer or independent supplier) for the period 1960 through June 1975. From 1961 through 1974, the percentage of parts provided by independent producers varied from a high of 45.3 percent in 1973 to a low of 41.9 percent in 1971; the variations during this period were minor and appear to be insignificant. However, the independents' share increased to 48.5 percent for the first six months of 1975 (the latest data available), but this period is not considered representative in view of the drastic production cut-backs that occurred.

The principles behind company "make or buy" decisions are relatively simple but the principles must be applied to a constantly changing real world. This constant change makes specific predictions concerning the economics of making or buying particular parts, over time, very uncertain.

6/ Use of vehicle manufacturer's available capital in meeting Government environmental, safety and fuel economy mandates over the next decade makes continued use of present sourcing highly probable.

To Make or To Buy. Company decisions concerning "make or buy" of individual parts are the result of the interplay of several related factors. [7/] The guiding principle and general frame of reference is the expected effect on the long run profitability of the company.

The following list of related factors is not all inclusive but include the more common factors affecting make or buy decisions:

1. The first consideration is the estimated cost of producing the part compared to bids submitted by independent suppliers;

2. Delivery schedules must be met to avoid disruption of production and the company must be satisfied that schedules can be met;

3. The company must be confident that quality control will be maintained. The reputation of an independent for providing parts which meet specifications must be balanced against a company's own experience in manufacturing similar products;

7/ For a more extended discussion of specific examples see report of testimony before the Sub-committee on Special Small Business Problems of the House Committee on Small Business, Washington, D.C., June 3, 1969.

4. Parts which have frequent changes in specifications are subject to special considerations because they require close coordination between the designers, production engineers and the production lines. When design changes are frequent - and with constant product improvement this is often the case - the part may be produced in-house to assure the needed coordination;

5. On the other hand vehicle producers may buy from independent suppliers to obtain the advantage of a particular technology which the vehicle company does not possess;

6. The long term need and investment requirements for special machines and tooling for parts production also influences decisions on whether to build capacity to produce the part or to buy from an independent supplier;

7. The effect of the decision on company employment and the reactions of employees and employee unions certainly has to be taken into account;

8. Other special considerations, for example an in-house production capability for dies can provide a source of skills needed for maintenance and repair of dies in production stamping plants; and

9. If sourcing outside the United States is considered, changes in exchange rates over time must be reckoned with.

All of the foregoing factors and many others must be considered on both a long run and a short run basis.

Investment cost is a consideration in sourcing decisions. For example, the Department of Transportation estimated the capital investment required to establish a 500,000 car manufacturing facility at approximately $2.1 billion.[8/] This amount includes only the costs of physical plant, equipment and tooling,and must be supplemented by the costs of design and development engineering, and distribution.

8/ Included in this total are (capacity - 500,000 cars):

Engine production line including foundry	$572.8 million
Transmission line	242.6 million
Stamping plant	409.3 million
Trim plant	138.4 million
Component manufacturing facilities	528.8 million
Final assembly	239.5 million
Total	$2,131.4 million

The Federal Task Force on Motor Vehicle Goals Beyond 1980, Draft September 2, 1976, page 6-5.

Innovations are so demanding in technical expertise and capital investment that the automobile manufacturers utilize increasing support from component suppliers. Resources adequate to develop and produce intricate and complex items are available only from the automobile manufacturers or large supplier companies.

<u>Production and delivery</u> schedules of the components must be matched to vehicle assembly line requirements if automobile production goals (10 million or more vehicles) are to be produced each year. Precise scheduling is essential whether the parts and components are supplied in-house or from outside sources.

The <u>reputation</u> of the vehicle manufacturer and continuing success of the company depend to a large degree on quality of the components. The car buyer is not directly interested in the original producer of any part. In case of failure or other difficulty the user looks to the auto manufacturer for satisfaction. Thus the vehicle manufacturer must be assured of strict adherence to specifications and quality control in production.

Importance of the buyer's interest in the quality of the car he purchases is equaled and sometimes exceeded by the Government's interest. Many Federal and local government agencies are issuing laws, regulations and

standards which dictate the specifications and quality of vehicles and/or their performance. The vehicle manufacturer is held liable for compliance and this fact is one of the several important influences in the decision as to the source of component supply, whether it be in-house or external.

The specifications for each part must be developed to assure compatibility with related items. The several components of the power train, for example, the engine, transmission, drive shaft, differential, axles, wheels and tires, must be compatible with each other and the assembly as a whole matched to the rest of the chassis so as to result in the desired vehicle performance. These components frequently are produced by different manufacturers thereby requiring the individual specifications to be carefully coordinated. The parts interrelationship in some instances dictates that control can be achieved only if the vehicle manufacturer designs and produces them.

With respect to overseas sourcing, changes in <u>exchange rates</u> over time, whether these be large and discontinuous as under pegged rates or small and continuous as under more flexible rates, may affect decisions whether to source outside the U.S. Where lead

times are long, the purchasing company may find it especially difficult to estimate the dollar cost of imported items. Should the dollar fall in value relative to the currency of the source country before the imports are actually delivered, the dollar cost of these imports might as a result increase sharply. The risk that this may happen reduces the attractiveness of foreign sources.

Changes in exchange rates may partially or totally offset the operation of factors that increase or reduce the competitiveness of foreign components vis-a-vis U.S. components. While a high rate of inflation in a source country might reduce its competitiveness as a source of automobile components, this effect could very well be offset by a fall in the value of the source country's currency relative to the dollar. Similarly, if a source country has percentage increases in productivity exceeding those in the U.S., that country's advantage could be offset by a rise in the value of its currency.

Major Suppliers. Among the major suppliers of parts and components to the auto, truck and bus assemblers are: Borg-Warner, Budd Company, Clark Equipment Company, Dana Corporation, Eaton Corporation, Federal Mogul Corporation, Gould, Incorporated, Kelsey-Hayes

Company, Lear Siegler, Incorporated, McCord Corporation, Rockwell International Corporation, A.O. Smith Corporation, TRW, Incorporated, The Timken Company and The Torrington Company. Selected examples of portions of total production going to the automotive industry are noted below.

Dana Corporation manufactures a wide variety of components and parts for the chassis, frames and power trains of automobiles and trucks. Typical of most component manufacturing companies, Dana has a variety of customers and 1975 sales were as follows: 28 percent to light duty truck manufacturers, 27 percent to service parts customers, 16 percent to heavy duty truck manufacturers, 14 percent to passenger car assemblers, and 15 percent to miscellaneous customers.

The Eaton Corporation's 1975 sales were about 30 percent in heavy duty truck transmissions, axles, brakes and engine parts.

The A. O. Smith Corporation is the world's largest manufacturer of automobile and truck frames. Automotive parts sales in 1975 accounted for about two-thirds of gross sales.

TRW, Incorporated's sales in 1975 were 10 percent in domestic car and truck products, 19 percent in international car and truck parts, and 10 percent in replacement car and truck parts. A total of 39 percent of total sales were to the automotive industry.

McCord Corporation in 1975 made 88 percent of total sales to the automotive industry.

Borg-Warner Corporation production of automotive components includes transmission clutches, four-wheel drive units, differentials, brake components, axles, carburetion and ignition equipment, emission controls, and radiators. In 1975 transportation equipment represented 38 percent of total sales.

Automotive products in 1975 accounted for 21.5 percent of Rockwell International total sales.

Cost of Materials and Components. The cost of materials and components, whether manufactured by internal divisions or subsidiaries or external suppliers, is an important factor in establishing vehicle selling prices. That is because 70 percent of the manufacturing cost of automobiles is represented by the cost of components. (The next biggest item of vehicle cost, only 8 percent, is identified as "product expenditures", that is, the costs incurred in annual model changes including design, tooling, plant change-over expense and new facilities amortization; 6 percent of cost is assembly labor and overhead, 5 percent is freight, 5 percent marketing, 4 percent warranty and 2 percent administrative and sales

expense). [9]

The Interagency Task Force on Motor vehicle Goals Beyond 1980 noted that automobile manufacturers do not, as a rule, break down materials and labor costs involved in the manufacture of components they buy. Instead, the total purchase price of components is used in pricing calculations which include other considerations such as consumer acceptance and competition as well. For example, labor costs and costs of iron, steel, copper, aluminum and other materials used in the manufacture of the engines, frames, bodies, etc., are not separately estimated. These elements are aggregated in the cost of the components.

Production Cycle

Engineering departments of the vehicle manufacturers, similar departments in the component and parts manufacturing companies, and other establishments of the industry continuously strive to improve the performance and appearance of their products. When the corporate managers decide that new concepts have been sufficiently developed and tested, the decision is made to incorporate them into production. Product changes are made: (a) to

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9/ Draft Report - Manufacturing and Maintenance Panel, Interagency Task Force on Motor Vehicle Goals Beyond 1980.

incorporate features of appearance or product improvement, (b) to facilitate manufacture, (c) to achieve a cost reduction, or (d) to comply with regulatory requirements. In every production period there are a number of such changes and in periods ranging from 4 to 12 years the corporations accumulate a group of more or less radical changes requiring the introduction of a new model. The process of implementing the changes results in "production cycles", that is, production of specific models continues with minor modifications for one year. Then production stops for the time required to change the factory tooling so as to introduce the innovations. The interval that a given model is being produced is identified as a production cycle.

Approximately one-third of all parts used in automobile assembly undergo some degree of design modification during an annual model change. Much of the new design is in modification of parts of the outer sheet metal. The time interval between major redesigns of all of the sheet metal components, or introduction of completely new model designs may vary from 4 to 12 years, as explained in the description of production cycle above. For an all new car 80 percent to 90

percent of the vehicle components will change, but generally not engines or transmissions. 10/

The total program involved in making a model year change includes decisions concerning production operations, planning, styling, engineering, financing, purchasing, designing and building production tools, and preparatory negotiations with suppliers. All of this takes from 3-1/2 to 4 years of lead time broken down approximately as outlined in the following paragraph.

The general program plan is developed about 208 "weeks before volume production", known in the industry as WBVP. Scale models, wind tunnel tests, advance engineering, styling are accomplished by 143 WBVP; final engineering, release for procurement of critical components and long lead time items 100 WBVP; engineering drawings for major components and parts released to production, 95 WBPV; tooling aids, 80 WBVP; final tooling starts 78 WBVP; final engineering drawings released by 40 WBVP; pilot car building starts 12 WBVP. 11/

10/ Draft Report - Manufacturing and Maintenance Panel, Interagency Task Force on Motor Vehicle Goals Beyond 1980.

11/ Manufacturing and Maintenance Panel Report, March 15, 1976.

In planning new models or model changes one of the most important and earliest questions to be considered must be the materials to be used, in terms of their availability, weight, safety and cost. Weight of the vehicle affects fuel economy, and fuel conservation is of prime importance.

Materials

Although the subject of materials is treated more fully in Chapter VI, the following comments are pertinent to any review of industry structure.

The 1975 automobile averages about 16.9 percent iron and 59.6 percent various alloys of steel. This is emphasized because of the inherent weight of the materials and their predominance in the composition of the vehicle.

Of the total weight 4.6 percent is rubber, 3.0 percent plastics, 2.3 percent aluminum and the balance is fractional percentages of zinc, copper, lead, body solder, and other materials.[12/]

There appears to be no supply problem with any of these basic materials with the possible exception of stainless steel. While some sources indicated a potential shortage of stainless steel after 1980, the International Trade Commission, in January 1976,

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12/ Motor Vehicle Goals Beyond 1980, Vol. 2, page 11-6 Table 11-1.

recommended that quotas be imposed on the importation of these alloys so as to protect the U. S. specialty steel industry.

The U. S. is dependent on foreign sources for several materials used in car production. While quantities may be relatively small, many materials are particularly essential for alloys. Such materials include manganese, chromium, cobalt, nickel, vanadium, zinc, and copper. The U. S. is also dependent on foreign sources for bauxite and several precious metals used in catalytic converters, i.e., platinum, palladium and possibly rhodium. Availability of sufficient quantities to meet U.S. needs of these materials is dependent on world economic and political factors.

Aluminum and plastics appear to be the most promising substitutes for the much heavier iron and steel to produce a lighter weight vehicle. The Aluminum Association, Inc. believes use of aluminum in 1977 cars will be 15 percent greater than in 1976 models. By 1980 aluminum content is expected to double from 100 pounds per car in 1977. This usage would replace about 505 pounds of steel in bumpers, floors, inner hoods and deck lids and engine intake manifolds. 13/

13/ "Automotive News", March 29, 1976.

Union Carbide Corporation, for example, has advertised successful development of an aluminum auto radiator to effect a 40 percent reduction of weight of that component.14/

General Motors, with the cooperation and technical assistance of major aluminum manufacturers, made a study of all aspects of sheet metal manufacturing of aluminum. Some conclusions reached were:

> "The hood assembly held the greatest potential for manufacture in aluminum because its function is nonstructural and because its size offers the greatest weight savings.
>
> "Aluminum cannot be used on the current hood design. Product redesign, including shape, is necessary.
>
> "Current requirements for welding aluminum are at least three times the requirements for welding steel.
>
> "Finally, quality problems were greatly magnified in the areas of fit, metal finishing and handling."15/

At the same time, during the Society of Automotive Engineers annual Congress and Exposition, February 1976,

14/ "Journal of Commerce, February 24, 1976

15/ "Automotive Engineering", March 1976.

Oldsmobile engineers stated they have been working on the first production system for substituting all-aluminum for all-steel hoods. The system is being installed in Oldsmobile assembly facilities in Lansing, Michigan, ready to use at the start of 1977 model year production. 16/

Also, at the S.A.E. Congress and Exposition, Chrysler Corporation displayed a light weight, experimental, high strength vehicle, namely a revamped Dodge Charger using a large amount of high strength low alloy steel and aluminum. These materials, substituted for the more conventional steels, reduced the car weight 630 pounds. 16/

Concurrently, General Motors Pontiac Division, using a 1975 Ventura as a starting base built an experimental "Phoenix" idea car using reinforced plastics to reduce the car weight 20 percent, that is, about 700 pounds. Glass fiber-reinforced urethane foam was used in front bumpers, a steel/plastic composite hood, plastic rear window, and wheels and structural members of new high glass content reinforced plastic. But General Motors' President, Elliott Estes, states that the plastic industry must improve the quality and surface finish of fiber reinforced plastics and must increase fiber content to give greater strength. "It takes about five times more hand labor to finish a Corvette than a larger steel bodied car." 17/

16/ "Ward's Auto World", March 1976.

17/ "Automotive Industries", March 1, 1976.

The average U.S. auto now contains about 100 pounds of plastics. Usage is expected to increase substantially after 1980. Improved manufacturing efficiency will assist attainment of thie end. 18/

However, as in most areas under discussion, no absolute predictions can be made concerning the materials to be used in 1985 cars.

Integration of Production and Trade in Automotive Products - United States and Canada

Since 1965 the structure of the automotive industry in the United States has been strongly influenced by the Agreement Concerning Automotive Products Between the Government of the United States and the Government of Canada (January 16, 1965). The purpose of the Automotive Agreement was to provide a virtual integration of the automotive industries of the two countries, and this has been essentially accomplished. Specifically, and quoting from the Agreement, three objectives were set forth: (a) the creation of a broader market for automotive products within which the full benefits of specialization and large-scale production can be achieved; (b) the liberalization of United States and Canadian automotive trade in respect to tariff barriers and other factors tending to impede it, with a view to enabling the industries of both countries to participate on a fair and equitable basis in the expanding total market of the two countries; and (c) the development

18/ "Automotive Engineering", March 1976

of conditions in which market forces may operate effectively to attain the most economic pattern of investment, production, and trade.

It was agreed that it shall be the policy of each government to avoid actions which would frustrate the achievement of the objectives of the Agreement. The Agreement is of unlimited duration, but each government has the right to terminate it by giving 12 months' notice.

The Agreement, as implemented in the United States by the Automotive Products Trade Act of 1965, and approved by Congress on October 21, 1965, resulted in the removal of U. S. duties on specified new and used Canadian motor vehicles and original equipment automotive parts.

<u>Before the Agreement</u>. The United States and Canada negotiated the Automotive Agreement in 1964 to head off potential bilateral conflicts over Canada's efforts to improve the performance of its relatively inefficient automotive industry. The high-cost Canadian industry had been structured to serve a small domestic market behind a high tariff wall. The measures Canada proposed to take to encourage production, such as duty remissions to Canadian manufacturers, were creating a serious irritant in our economic relationship.

Under those circumstances it seemed desirable for the two countries to agree on a mechanism that would allow Canada to develop a more rational and efficient automotive industry but would not adversely affect U. S. industry. The resulting Automotive Agreement created the basis for an integrated automotive market by, in effect, removing duties on trade between the two countries in specified motor vehicles and original equipment automotive parts.

After the Agreement. Total U. S. exports of automotive products to Canada in 1964 amounted to $640 million, while total imports were valued at $76 million. In 1975 U. S. exports of automotive products to Canada had increased to $7,643 million and total imports increased to $5,801 million. Table 4-3 in the Appendix indicates the growth of automotive trade between the two countries since the agreement was signed. Differences in automotive trade are customarily measured in total, rather than in terms of "vehicle" trade or by "parts and components" trade. Each is a part of a whole, neither of which exists without the other. Nevertheless, the practice of separating the two for trade balance purposes sometimes exists.

The following Table contains exports and imports of Motor Vehicles and Motor Vehicle Parts, separately, by years 1965 to 1975. Motor vehicle exports to Canada increased in value from $142 million in 1965 to $3,064 million in 1975; imports from Canada rose from $78 million in 1965 to $3,726 million in 1975.

United States Automotive Trade With Canada, 1965-76 1/

(Millions of dollars)

Year	Motor Vehicles U.S. Exports	Motor Vehicles U.S. Imports	Parts and Components U.S. Exports	Parts and Components U.S. Imports
1965	142	78	738	139
1966	355	451	1,011	360
1967	666	920	1,216	474
1968	923	1,483	1,684	783
1969	976	2,079	2,134	959
1970	894	2,038	2,019	1,080
1971	1,319	2,511	2,448	1,481
1972	1,579	2,778	2,866	1,795
1973	2,082	3,061	3,552	2,172
1974	2,573	3,482	3,980	1,997
1975	3,064	3,726	4,409	2,008

1/ Table 4-3 in Appendix; U.S. Department of Commerce. Parts and components include both original equipment and replacement parts.

The United States exports of parts and components to Canada were $738 million in 1965 and $4,409 million in 1975. United States imports of parts and components from Canada were $139 million in 1965 and $2,008 million in 1975. Total parts and components exported from the

United States to Canada increased by 497 percent from 1965 to 1975, while imports increased by 1,334 percent Although imports of parts increased at a faster rate than exports during this period, the net difference of exports over imports of parts reached about $2 billion in 1974 and about $2.4 billion in 1975.

With respect to original equipment parts only, the following table shows the Trends of U. S. Import Trade since 1966 by source (motor vehicle manufacturers and independent parts manufacturers); the table also shows the trend of total U.S. consumption of original equipment parts, with all columns indexed to 1966.

Trends in U. S. Imports of Original Equipment Parts and Components from Canada and United States Consumption 1/

(1966=100)

	U.S. Imports from Canada			
Year	Motor Vehicle Manufacturers	Independent Parts Producers	Total	Total U.S. Consumption
1966	100	100	100	100
1967	118	151	129	88
1968	177	290	217	102
1969	197	381	263	108
1970	227	444	305	89
1971	328	534	402	118
1972	403	669	498	130
1973	421	847	573	154
1974	384	758	518	149
1975	361	741	497	153

1/ Derived from Table 4-4 in Appendix. Above amounts represent relatives based on 1966 as 100; e.g. total U.S. consumption in 1975 was 153 percent of the 1966 level.

Correspondingly the next table (following) shows similar data for trends in U. S. export trade and total Canadian consumption of original equipment parts.

Trends in U. S. Exports of Original Equipment Parts and Components to Canada and Canadian Consumption 1/
(1966=100)

Year	U.S. Exports to Canada: Motor Vehicles Manufacturers	Independent Parts Producers	Total	Total Canadian Consumption
1966	100	100	100	100
1967	105	109	106	110
1968	150	145	149	146
1969	210	174	197	169
1970	171	180	174	142
1971	208	172	196	163
1972	242	200	227	181
1973	288	271	282	211
1974	353	307	337	249
1975	395	373	387	286

1/ Derived from Table 4-5 in Appendix. Above amounts represent relatives based on 1966 as 100.

In both the United States and Canada imports have increased at a higher rate than domestic consumption of original equipment parts and components. For the United States, consumption in 1975 was 153 percent of the 1966 level in contrast to imports from Canada which were 497 percent. In 1975 imported parts produced by motor vehicle manufacturers were 361 percent of the 1966 level as compared to 741 percent for parts imported from

independent parts producers. For Canada, 1975 consumption of original equipment parts was 286 percent and imports from the United States 387 percent of the 1966 levels.

The trend of the net balance of overall automotive trade reversed during 1976; the net balance of $1.8 billion in 1975 dropped to $1 billion in 1976. 19/

Distribution

Automobiles and trucks usually are distributed to the users by independent dealers or businesses whose principal function is the sale and servicing of vehicles. A dealer is awarded a franchise by the manufacturer and the arrangement is supervised for the corporation by managers working out of regional or district offices. In some instances an additional intermediary is used, that is, a distributor who may arrange subcontracts with more than one dealer. Factory branches for distribution of the vehicles are losing favor and are being replaced by distributors and dealers. "Automotive News" 1975 Almanac Issue reports that there were over 25,500 car and truck dealers in the U.S.

19/ Eleventh Annual Report of the President to the Congress on the Operation of the Automotive Products Trade Act of 1965.

In some instances automobile and truck manufacturers reserve the right to sell directly to owners of large fleets of vehicles. Even in such instances a local distributor or dealer may have to be involved in some way so as to be in a position to provide for possible warranty or other service demands.

Aftermarket

The aftermarket is the segment of the automotive industry that provides replacement spare parts, services to install them and services to maintain and repair the vehicles so as to keep them in proper running order. The complexity of operation of these facilities is magnified not only by advances in automotive technology, but more particularly by the mandates of U. S. Government rules, regulations and specifications intended to reduce air and noise pollution, conserve energy and improve safety. Each of these objectives require more sophisticated vehicle components which affect dealer inventories and demand new skills of the mechanics.

MVMA's "1975 Automotive Facts and Figures" divides the aftermarket industry into several categories. The following table applicable to calendar year 1972 is drawn from this source and tabulates the pertinent categories. In addition to these categories, gasoline

dealership employment exceeded 900,000 and the trucking industry employed more than 9 million workers. Employment in vehicle related jobs in the U. S. amounted to 10 times as many as are employed in direct manufacture of the vehicles.

Selected Automotive Aftermarket and Related Activities Industry[1/]

Industry Classification	No. of Establishments	No. of Employees	Payroll (Millions)	Receipts (Millions)
Wholesale	36,468	391,849	$3,414.6	$83,015.8
New & Used Vehicle Dealers	32,452	773,912	6,843.0	73,309.2
Used Vehicle Dealers	31,785	66,081	256.4	4,524.0
Auto. & Home Supply Stores	37,510	188,346	1,103.1	7,542.8
Repair Shops	127,203	345,659	1,699.3	7,045.1

1/ 1975 Automobile Facts and Figures Motor Vehicle Manufacturers Association (1972)

There are three principal sources of supply of replacement spare parts, namely, the original automobile or truck manufacturers, independent parts and components manufacturers, and rebuilders. The last named are a rapidly increasing element because their type of operation permits them to sell replacement parts at prices substantially below the competition, the original equipment manufacturers and independent parts and components manufacturers. Rebuilders generally require their customers to exchange a worn or damaged part for the rebuilt part they are purchasing.

There are five types of distribution outlets for the replacement parts provided by the aforementioned suppliers. These centers are: automobile and truck dealers, warehouse distributors and jobbers, oil company outlets, company chains specializing in certain types of components and/or repairs, and mass retailers.

Most car and truck dealers maintain parts departments to supply replacement needs of their vehicle customers and users. Warehouse distributors concentrate on large lot sales and sell to jobbers who specialize in smaller volume transactions. Oil company outlets are the gas stations, many of which sell tires, batteries, car accessories and other parts to supplement their fuel and lubricant sales. Specialist chains such as "home and auto" stores are outlets for certain specific components

such as mufflers, seat covers, and transmissions. Mass retailers include large department stores and mail order firms.

Vehicle dealers, some oil company outlets and mass retailers generally have mechanics on their staffs to install them and to provide other services.

In addition there is a very large and important servicing element that does not cater to customers outside its own establishment. This refers to the repair shops of large fleets, such as car and truck rental firms, large wholesale and retail chains, trucking companies and the like.

The automobile manufacturers, Motor Vehicle Manufacturers Association, dealers and their association, the National Automobile Dealers Association and others are strongly supporting the National Institute for Automotive Service Excellence. This organization arranges for testing of automotive mechanics in several specialty areas such as engines, transmissions, electrical systems, fuel systems, steering and front end systems, body repair, etc., and those who qualify are so certified. Many thousands of U. S. mechanics are studying and subsequently qualifying as certified mechanics each year under this program.

CHAPTER V

GOVERNMENT REGULATIONS AND TECHNICAL FACTORS

The automobile of the 1980's will include significant innovative features in response to market demands and government regulations in the areas of fuel economy, exhaust emission controls, damageability, noise, and safety standards. Since some regulations limit the industry's ability to meet other goals, these three topics (fuel economy, emission control and safety) and their interplay are discussed in this chapter. A particular complaint within the industry is the problem of complying with environmental emission regulations while modifying auto fleet characteristics sufficiently to meet the increasingly stringent fuel economy requirements of the Energy Policy and Conservation Act of 1975. Many of the initial changes to accomplish these twin objectives will be modifications of the vehicle other than the engine. Even here, constraints are met by needed structural strength and design changes to meet safety and damage limitation requirements.

The major changes to obtain fuel economy in the period to 1980 will occur in auto weight and structure, with less in buying patterns and least in engine changes. In the post-1980 period major changes may be possible in engine/transmission systems. Of the four engine types beyond

1980, two (the traditional and diesel engine) have serious emission control problems, while the other two (gas turbine and Stirling), although requiring major breakthroughs in design and materials, appear to have the capability of meeting statutory emission standards. The latter also have multi-fuel capability, and the Stirling is highly promising from the fuel economy and noise standpoints as well. Two engines, the diesel and the turbine, have inherent noise defects to be controlled. In the safety field, crash avoidance probably will include changes to braking systems, lighting and field of view.

Fuel Economy.

The Energy Policy and Conservation Act of 1975 (Public Law 94-163)[1/] amended the Motor Vehicle Information and Cost Savings Act (15 USC 1901 et seq) to, *inter alia*, set the minimum accepted average fuel economy for the automobiles manufactured by any manufacturer for any model year. The following requirements and definitions concerning economy are taken from that Act.

The average fuel economy for passenger automobiles manufactured by any manufacturer in any model year after model year 1977 shall not be less than the number of miles per gallon (mpg) of gasoline equivalent listed in the following table.

1/ U.S. Congress, Public Law 94-163, Energy Policy and Conservation Act of 1975, December 26, 1975.

Model Year	Average Economy in mpg
1978	18.0
1979	19.0
1980	20.0
1981,82,83,84	To be set by Secretary of Transportation
1985	27.5

While some modification will be allowed in these national values after 1985 and for individual manufacturers under certain conditions, this discretion is limited. For example, the Secretary of Transportation may set a different standard for any model year after 1984, but if the value falls outside the range of 26.0-27.5 mpg, Congressional review is required.

It should be noted that the fuel economy standard is not set for each automobile model but for the average of the automobile fleet actually produced by each manufacturer for that model year. Definitions under the Act are:

> Model year, (in U.S. generally August through July) is defined as the manufacturer's annual production period that includes January 1 of the specified year. If the manufacturer does not have an annual production period, the term model year is equivalent to manufacturers production during the specified calendar year.

Model type is a particular class of automobile as determined, by rule, by the EPA Administrator after consultation and coordination with the Secretary of Transportation.

Fuel economy is defined as the average number of miles traveled by an automobile per gallon of gasoline (or equivalent amount of other fuel) according to the following procedures. Fuel economy for any model type in any model year shall be measured in accordance with testing and calculation procedures established by the EPA Administrator. These procedures shall be those utilized by the EPA Administrator for model year 1975, or procedures that yield comparable results. The 1975 procedures were weighted with the urban cycle at 55 percent and the highway cycle at 45 percent.

Gasoline equivalents shall be set by the EPA Administrator to define the quantity of any other fuel that is the equivalent of one gallon of gasoline.

As can be seen by these definitions and requirements, the automobile manufacturer sets his strategy concerning the minimum fuel economies that he plans to achieve for each automobile model based on his anticipated sales mix among all of his manufactured model types for any given model year. To conduct an analysis of these economies and likely steps to meet them, a manufacturer must define typical model types, expected mixes of types in the model year fleet and general characteristics of model types. For the purposes of this paper, this is done for the national auto fleet, rather than for individual manufacturers' fleets.

Model Types. As noted above, the automobile manufacturer must base projected fuel economies upon model type mixes comprising a fleet total, and consequently at this point we review the structure of model type and fleet characteristics. The Interagency Task Force on Motor Vehicle Goals Beyond 1980 (TF-80), Panel on Marketing and Mobility [2/] provides an analysis of model types that have been used in various studies for market classification.

2/ Energy Resources Council, Interagency Task Force on Motor Vehicle Goals Beyond 1980, Draft Final Report and Panel Reports, Office of the Secretary of Transportation, Department of Transportation March 1976.

The number of model types in nine studies varies from 3 to 8. When consideration of price is dropped from the determining variables the list is usually 3-5 models. For the Interagency Task Force on Motor Vehicle Goals Beyond 1980 (TF-80) analysis, the model type criterion was set based on "roominess" of the passenger compartment; three model types were established (small, medium and large). Based on the actual models available for model years 1973-1975, the vehicle weight correlated well with roominess allowing for the following categorization for present model years:

Small	less than 3050 pounds
Medium	3050 to 3500 pounds
Large	more than 3500 pounds.

A similar classification was used in the Jet Propulsion Laboratory study "Should We Have a New Engine?" sponsored by the Ford Motor Company (JPL study)[3/] which uses the same three categories, and for some data divides the small category into

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3/ Jet Propulsion Laboratory, California Institute of Technology, "Should We Have a New Engine?", Volume I and II, August 1975 (sponsored by Ford Motor Company).

small and subcompact. In this chapter these categories will be used to group model types. It should be noted that the weight division will not be constant over model years but will be reduced and will further vary based on the type of engine incorporated.

Auto Fleet. Consideration of auto fleet here has two elements. For the majority of the analysis elements, including fuel economy, auto emissions and safety, the fleet of interest is the model year fleet (the mix of model types of a specific model year that are purchased). However, for the two aggregate considerations, ambient air quality and projected total fuel consumption, the entire set of autos-in-use must be considered. This second definition must include assumptions as to rates of auto replacement by year after manufacture, auto fleet growth rates and changes in miles of operation as the auto ages. Thus the auto-in-use fleet definition is actually a representation of auto miles traveled by model type and model year, for all model years having a significant number of autos in use.

Methods to Improve Fuel Economy. The means available to meet the legislated fuel economy levels fall into three general areas. While the industry has only limited influence on the first of these, the latter two can be implemented by the manufacturer. The measures are:

- o modify buying and miles-traveled patterns among the model types.
- o change structural and material elements to reduce auto weight, aerodynamic drag, etc.
- o make major changes to the engine-transmission systems.

In the near term (say through 1980) the major elements of change will probably occur in auto weight and structure, less in buying patterns and least in engine changes. In the post-1980 time frame, radical changes are more likely to occur in engine/transmission systems, with a second phase of vehicle down-sizing probable during the 1981-85 period. Engine changes are particularly critical since extensive development and commitment by a manufacturer is required if a major change is to be made from the traditional gasoline engine to new engines that will satisfactorily meet fuel and emission regulations.

While the pace of innovation will continue to be constrained by economic and technological realities, increased consumer demand for fuel economy, as well as the mandatory regulations for both fuel economy and for emissions control, will probably foster development of new systems and automobile modifications in an accelerated time pattern relative to past experience. Even if the programs are accelerated, considerable uncertainty will continue to exist since accelerated programs often experience new problems.

Factors influencing buying patterns are many and result in additional uncertainty about consumer acceptance of new vehicle types. For example, a buyer's acceptance of changes in passenger compartment "roominess" as well as many other design features will undoubtedly affect future demand for smaller cars. The willingness of the buyer to accept smaller compartments is hard to estimate in the long term and is very dependent on changing family size, driver age distribution, etc. 4/ Trends are toward smaller model types, and these will be strengthened by higher new car costs, but the extent of change is difficult to project.

4/ The factor discussed here is buyer willingness to accept a smaller class model type. In a later section smaller autos within model types are discussed.

Intermediate Period Vehicle Changes. The primary changes in auto fleets prior to the 1981 model year will be in terms of body design characteristics, buyer preference and levels of their use by the public. Relatively minor engineering improvements will continue to be made in engines, but in the three year (summer 1976 - fall 1979) time frame, no radical changes in the power plant are possible due to the production lead times necessary for an engine line changeover.

Fleet Mix Changes Due to Buyer Preference. The increasing price of automobiles and fuel, increasing concern about energy conservation, and the changing household composition all point toward continuance of a general trend toward purchase of smaller auto model types.

One report (JPL) has projected the trend in purchases for model year 1980 as shown in the following table.

Size Mix of Auto Purchases Estimated for 1975 and 1980
(in percent)

Purchase Year	Model Type: Small	Subcompact	Compact	Full Size & Large1/	Mean Weight
1975	9	8	18	65	3840 lbs.
1980	15	25	25	35	3275 lbs.

Source: Jet Propulsion Laboratory (JPL), California Institute of Technology, "Should We Have a New Engine?", 1975.

1/ Includes "intermediate".

It should be noted that projections are for model types;the types will show other change as discussed later. Related savings in fuel economy are not discussed here; for this "buyer preference" effect, the autos of the future are assumed to have similar fuel economies by type to the 1975 autos.

For the three categories of the TF-80 report, the 1980 mix is forecast as 25 percent small, 25 percent medium and 50 percent large.

Since auto fleets are not replaced all at one time but progressively over a period of years (see following table), a period of approximately 10 years will be required for the full impact of this buyer shift to be felt. Assuming that the buying pattern would change at a constant rate from 1975 to 1980 and then remain the same, this single effect would create fuel savings of about 6 percent in 1980, 12 percent in 1985 and 15 percent in 1990.

Mean Vehicle Cumulative Survival Availabilities

Vehicle Age (years)	Cumulative Probability 1/
1	1.000
2	.992
3	.982
4	.965
5	.939
6	.898
7	.831
8	.726
9	.597
10	.453
11	.328
12	.231
13	.162
14	.113
15	.080

1/ For example, in 1975 of all the autos purchased in the 1965 model year, 45.3 percent remain in operation.

Source: JPL.

In addition to the buying pattern, a factor that is controlled primarily by the user is the amount the auto is driven. While this is not a prime factor in auto design, it both promotes the mix of model types purchased and is affected by the model type mix. Further, it has a major impact on energy consumed in transportation and levels of pollutant emissions. During the energy crisis of 1973-74, a significant reduction in annual auto vehicle miles traveled (VMT)

occurred. Recent statistics on gasoline consumption suggest the effect was principally short-term. If a long-term conservation program were to be accepted by the public to reduce auto use, savings in fuel, on an annual basis, could be similar to the savings caused by the projected new auto buyer preferences. Assuming that a trend toward reduced auto usage, caused by gasoline rationing or increased fuel prices, occurred in the late 1970's, reaching a VMT reduction of 15 percent by 1985, total gasoline savings on an annual basis from new auto buyer patterns and conservation would be about 13 percent in 1980, 27 percent in 1985, and 30 percent in 1990.

The figures in the table following put the potential fuel savings in perspective by comparing 1975 gasoline consumption with three alternate projections to 1980 and 1985.

Automobile Gasoline Usage in BTU x 10^{15} 5/

Year	No Change	Buyer Change	Buyer/VMT Change
1975	10.0	--	--
1980	10.8	10.2	9.4
1985	11.2	9.9	8.2

5/ The measurement of a British Thermal Unit (BTU) is so small it must be multiplied to assist understanding the value,in this instance, multiplied by 10 to the 15th power.The procedure is common in industry. JPL used this specific formula.

If these forecasts are met, annual fuel consumption by the auto fleet over the next decade will remain reasonably comparable to present levels due to auto buyer preference changes alone and would be reduced in direct proportion to the annual reduction in VMT's. Therefore, actual savings in total annual energy use as compared to present consumption can be expected as manufacturers modify their model types. These modifications may reflect customer demand, state-of-the-art progress and Government mandate.

Structural Modifications. During the intermediate period, the primary factors in improving fuel economy will be vehicle weight reduction, increased use of 4-speed manual or automatic transmissions, reduced acceleration capability, improved ignition timing controls, reduced aero-dynamic drag and changes in tires and accessories. Within these factors, the weight reduction factor represents about 50 percent of the fuel economy potential.

Areas for Weight Reduction. The intermediate period weight reduction programs are in evidence in 1976 model year automobiles and will continue to appear for the next 5-6 years.

The primary potential for weight reduction within model types is in terms of reduction of the exterior vehicle size while retaining a reasonably constant size for the passenger compartment. These changes will affect both auto length and width, with the primary changes occuring in door widths, angles of windshields and side windows, engine compartment sizes, chassis design, and power train modifications. Combined with the reduction in total weight, engine changes involving V-configuration and other size reductions will provide the smaller engine space requirements.

Not all of the changes will occur in all vehicle models, of course, and some new equipment will be added to reduce the loss in rider comfort as the vehicle is lightened. The net weight savings have been estimated to range from 6 percent for small vehicles to 15 percent for large models. 6/

In addition to the structural reductions, further weight savings can occur due to changes in materials used in the auto; for the intermediate period these include greater use of high strength low-alloy steels and plastics plus some additional use of aluminum. The

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6/ Jet Propulsion Laboratory, California Institute of Technology, "Should We Have a New Engine?", Volume I and II, August 1975 (sponsored by Ford Motor Company).

materials change and the exterior size reduction make up the major weight savings. An estimate of practical weight savings for each model type is provided in the following table.

Categories and Maximum Extent of Weight Reduction for the Intermediate Period
(Percent)

	Model Type			
Cause	Small	Subcompact	Compact	Large
Exterior	5	9	10	15
Materials	3	3	4	5
Design Detail	-	2	2	3
V-6 Engine 7/	-	-	4	-

7/ Other smaller engine configurations could also be considered.

SOURCE: JPL.

Other Intermediate Period Modifications. While the 4-speed manual transmission provides a fuel economy advantage of about 10 percent compared to the 3-speed automatic transmission, the market acceptability of the 4-speed is limited except for small cars. An alternate transmission improvement would be a 4-speed automatic transmission with or without torque converter

lock-up [8] in the upper three gears. This would provide a projected 4-8 percent fuel savings over the 3-speed automatic transmission plus increase the acceleration capability.

Reduction in acceleration capability can be readily attained using lower-horsepower engines in many larger models. Even in some of the smaller models, sacrifice of some performance will provide fuel economy.

Aerodynamic drag improvements, tire friction reductions and improved accessory power systems provide the remainder of the potential non-engine fuel economy improvements. The JPL report suggests that the drag coefficient could be lowered 25 percent resulting in fuel economies of 2.5 percent. The substitution of radial tires, which have been adopted on most models in place of bias ply tires, improved fuel economy by 2.5 percent. Significant engine accessory savings are likely, primarily in the air conditioning and fan systems.

A composite of fuel economies due to the structural changes that are possible in the intermediate period is provided in the following table.

8/ At a road speed predetermined by engineers, power transmission becomes a positive, mechanical drive, eliminating the less efficient fluid drive of the torque converter.

Fuel Economy Potential Due to Structural Change in the Intermediate Period
(Percent)

Change	Vehicle Classification: Small	Subcompact	Compact	Large
Weight Reduction	6	10	15	18
4-Speed Transmission with Lock-up	3	6	7	8
Reduced Acceleration	2	2	5	10
Aerodynamic Drag	2	3	3	2
Accessories	1	1	2	3
TOTAL 9/	14	20	29	35

SOURCE: JPL.

Intermediate Period Engine Changes. During the period prior to the 1980 model year, no new engine types will be produced on other than an experimental basis. Therefore, the remaining power plants available in this period are improved gasoline and diesel engines.

9/ Some factors are interdependent, therefore, the fuel economy gains are not necessarily additive.

Engine modifications, other than reduction of horsepower that was discussed earlier, include improvements in the fuel induction system plus required emission control devices for the traditional reciprocating engine. These two systems are closely connected in their development and are influenced by the specific emission control standards that are set as national federal standards.[10/] Fuel induction improvements that will be introduced during this period include advanced carburetors (variable venturi, and possibly ultrasonic or sonic), electronic fuel injection and more advanced pre-heated fuel/air mixes. The emission control systems actually used will be dependent on the regulated level of nitrogen oxides (NO_x). If one of the stringent levels is in effect (.40 or 1.0 grams/mile), a three-way catalyst converter or dual oxidizing and reduction catalyst converter system will be required together with exhaust gas recirculation (EGR). If less-stringent standards for NO_x are maintained, the oxidation catalyst or thermal reactor will be required with EGR and possibly air pumps in a number of applications. Successful development of a lean burn concept could result in eliminating catalysts from some applications.

10/ U.S. Congress, Public Law 91-604, Clean Air Act of 1970, December 31, 1970.

Current production Wankel engines do not have good fuel economy primarily due to housing/seal problems and also present hydrocarbon emission problems. While some market penetration may occur if these problems are reduced, the expected impact is minimal.

Another existing alternative to the spark-ignition engine is the diesel engine. Potential diesel engine developments include increased application of turbochargers. Passenger car usage before 1980 will be on a limited basis. It has been estimated by various technical authorities that fuel savings of naturally-aspirated diesel versus conventional gasoline engines would range between 20 and 45 percent. Since there are uncertainties about the diesel engine meeting mandated NO_x emission levels, the market penetration by the diesel will be slowed.

Since buyer preference changes alone would maintain annual fuel usage without significant increase, the changes here suggest that a definite reduction in demand for gasoline will occur. Assuming that the 1980 fleet will for the most part still be powered by the spark-ignition, reciprocating engine, the 1980 model year use of gasoline should be 29 percent lower

than in 1975. By 1980 over 50 percent of all cars should be post-1975 models so that the yearly increments toward smaller autos within model types will be reflected in the majority of cars-in-use.

Design Options Beyond 1980. If the intermediate period changes discussed above are realized by 1980, the post-1980 period can include further vehicle innovation in the areas of body change and engine design. Unlike the 1976-1980 period, the major change is likely to be in engine types with major commercialization occurring after 1985. Weight reduction trends due to the materials substitution will continue and significant fuel economy savings may be achieved through transmission improvement.

Material Substitution Changes. The primary materials change in the post-1980 period may be substitution of plastics and aluminum alloys for steel. At present aluminum makes up about 85 pounds of an average auto weight; by 1985 this could increase to about 300 pounds replacing 525 pounds of steel, a net reduction of 225 pounds. This substitution thus could mean a 7 percent reduction in total auto weight from today's average.

Non-Engine Changes. The JPL analysis assumed a 4-speed automatic transmission for the intermediate period; in the 1980's a further evolution to a continuously variable transmission (CVT) is possible. The CVT's are conservatively projected to provide up to a 15 percent fuel saving over today's transmission or an additional 7 percent fuel savings over 1980's unit. Fuel savings due to non-engine changes by 1985 are shown below. These figures should be viewed with caution as other technical authorities consider that the estimates are too high for weight reduction and reduced acceleration.

Maximum Fuel Economy Savings Due to Non-Engine Changes: 1975 to Late 1980's
(Percent)

Change	Model Type			
	Small	Subcompact	Compact	Large
Weight Reduction	12	21	23	25
Transmission (CVT)	10	13	14	15
Reduced Acceleration	2	2	5	10
Aerodynamics	3	3	3	2
Accessories	1	1	2	2
TOTAL 1/	26	35	40	45

1/ Some factors are interdependent, therefore the fuel economy savings are not necessarily additive.

SOURCE: JPL

New Engine Options. In the 1980's there will be several options for new engines and for improvements in present engine types that are dependent on the success of research and development programs presently underway. Prior to 1985, improvements may be made in both spark-ignition and diesel compression-ignition engines. By 1985, the TF-80 report suggests that the Brayton and Stirling cycle engines may have progressed sufficiently to be in commercial production. Both the JPL and TF-80 studies anticipate the primary engine for post-1985 autos will be the Stirling engine, assuming that R&D is successful, due to its high fuel economy and its low emissions. If ceramics research is also successful, the gas turbine (Brayton) engine would be competitive in both fuel economy and emissions with the Stirling.

Engines that are not expected to be competitive or fully developed by 1990 would be the Rankine cycle (steam), the electric and the electric-hybrids.

The diesel engine in a 1985 design would continue to have better fuel economy than the traditional engine but is likely to be ruled out as an acceptable alternate due to its inability to meet the more stringent NO_x emission standards. Even if the NO_x standards are relaxed, it remains marginal in this respect. Since the diesel is not an acceptable long term solution unless NO_x

emission standards are relaxed, its use in both 1980 and post 1985 autos may be limited. If a manufacturer changed from the present traditional engine to the diesel in 1980 and then to another engine in 1985, the rates of commercial acceptability and factory assembly line changes might cause major commercial problems.

The Stirling engine is a continuous combustion engine in which heat is transferred to a separate closed system of high pressure gas to drive a piston by alternating cooling through expansion and heating through compression. Most of the heat energy of the expansion subcycle is recycled. For continuous combustion engines, emissions are very low, running less than 50 percent of the most stringent statutory standards for carbon monoxide (CO), hydrocarbons (HC), and nitrous oxides (NO_x). If ceramics research does not succeed in time for 1985 use in other engines, the fuel economy of the Sterling engine will then be the highest of all engines, ranging from 25 mpg for large autos to 39 mpg for small autos based on 1975 model weights.

The gas turbine engine (Brayton cycle engine) is also a continuous combustion engine, meeting HC and CO emission standards with ease and having potential fuel economies. Prior to successful commercialization

of ceramics in engines, the Stirling should have higher fuel economy, but with successful ceramics use, some gas turbine configurations would be slightly more efficient and all turbines should be of equal fuel economy with the Stirling engine.

The engine candidates for the period to 1985 will continue to be conventional gasoline and increasing numbers of diesels. Stirling and Brayton engines are not likely to be introduced to production at a significant volume by 1985.

Types of Engines of Potential Use in Major Portions of the Model Year Fleet

1975	1980	1985	1990
Traditional	Traditional	Stirling	Stirling
	Diesel	Gas Turbine	Gas Turbine
		Traditional	Traditional
		Diesel	Diesel

Source: JPL.

The TF-80 report compares average fuel economies for the 1975 engine (moderate acceleration performance) with the advanced Stirling and traditional engines. The economies for a range of 1975 vehicle curb weights, with

"advance" engine projections are shown below.

Fuel Economy by Engine Type and Auto Weights
(Average)

1975 Curb Weight	Traditional 1975	Advanced Traditional	Advanced Stirling
2000 lbs.	27 mpg	33 mpg	39 mpg
3000	20	24	28
3500	18	21.5	25
4000	18	19	23

Source: Jet Propulsion Laboratory.

Thus, it can be seen that the non-engine changes, and the improved engine, projected for the 1985 model year suggest that fuel economies on the order of a 50 percent or more increase in miles-per-gallon are conceivable for most model types. Based on engine changes alone, the improvements are about 20 percent for changes to the traditional engine and 40 percent if the advanced Stirling or gas turbine engines are realized. Fuel economy improvements due to weight reduction, transmission and other non-engine changes are projected to range from 25 percent for small autos to 45 percent for large vehicles.

Emission Controls and Environmental Effects.

A major force in causing technological change in engines will be the emission control standards set in Federal regulations. There are two factors to be considered: first, the legislated standards for emissions and, second, still tighter regulations in some areas so that pollution residuals from all air emissions are low enough so that the area can meet air quality standards. These emission regulations could be imposed not only in the category pollutants of CO, HC, and NO_x, but also with other pollutants such as particulates, sulphur oxides (SO_x) and heavy metals such as lead. Another environmental consideration for automobiles is the level of noise associated with the vehicle. All of these elements are covered later.

Presently Controlled Emissions. In the Clean Air Act (PL 91-604), five air pollutants are specified as requiring controls to meet air quality standards. These are total suspended particulates, oxides of sulfur (SO_x), carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO_x). The first two are produced primarily by stationary sources, and no auto emission standards are set for them. For the last three a

schedule of progressive levels of control has been set with final statutory levels under current legislation being imposed by 1978. The automotive industry has stated it cannot meet these levels by the 1978 model year and accordingly has requested legislative relief.

While delays can be expected in compliance dates set for HC, the final compliance level is generally accepted. However, this is not the case for CO and NO_x, for which final levels of 3.4 and 0.4 grams/mile have been legislated.

Carbon Monoxide (CO) emissions clearly damage air quality and autos are a large contributor to CO levels in urban areas. However, the stringent statutory standard of 3.4 grams per mile is regarded by some authorities as more rigorous than necessary to protect public health. Accordingly, a legislative proposal has been introduced to relax the final CO standard to 9 grams per mile.

Hydrocarbons (HC) are controlled as emissions because certain types react in sunlight and certain atmospheric conditions to produce oxidants, a major constituent of smog. Emission controls are set for all hydrocarbons, rather than just those that react to produce oxidants. The legislated final standards for HC are 0.41 grams per mile.

Nitrogen oxides are controlled for two reasons: the level of NO_x in the atmosphere contributes to smog formation and nitrogen dioxide (NO_2) increases the incidence of respiratory illness. The present legislated emission level for NO_x emissions is set at 0.4 grams/mile but alternative levels ranging from 1.0 to 2.0 grams/mile are being debated. The final level selected may have a major effect on the type of engines that may be used in autos in the 1980's. The diesel, for example, is not expected to be capable of meeting the lower standard.

Another emission from gasoline engines scheduled to be controlled is lead. Two methods of control are already being used. In all new autos, a catalytic converter requires that non-lead gasoline be used. EPA regulations limit lead content of all gasoline to .5 grams/gallon by 1980. Thus the lead emission controls, unlike the controls discussed above, result in the removal of lead from the fuel rather than the control of the pollutant after combustion in the engine.

Other Pollutants. It is possible that additional pollutants in exhaust emissions may be controlled at a later time. There are two situations that could cause this.

First, the control of some of the present emissions using catalytic converters has caused increased amounts of sulfur oxide (SO_x) to be generated. The EPA has stated that this new pollutant source need not be considered through 1979 but left open the question of required emissions treatment at a later time. If the pollutant does come under regulation (like lead) the gasoline could be "desulfurized" prior to use. Alternatively, the auto emission controls might be modified or increased to remove this emission after the catalytic converter stage.

The second possible area of new controls involves particulate emissions. Automobiles are a relatively minor contributor to particulate emission levels, but there are some local areas where the authorities believe that atmospheric and other conditions accentuate the problem. These areas establish State implementation plans that are based on broad Federal guidelines. Tightening of the controls at both Federal and State levels is possible. Another air pollutant, odor, is not regulated. If diesel engines increase in use, this pollutant (odor) may become an urban irritant that could lead to new sets of controls.

Emission Control Devices. Pollutant emissions can be controlled using a series of techniques according to the type of engine. The primary emission control device after combustion is the catalytic converter, which through a chemical reaction, oxidizes the CO and HC to an acceptable emission level. An additional exhaust treatment is recirculation of the exhaust gas to the combustion chamber intake to reduce combustion temperature and thus retard formation of NO_x.

If current research and development effort on the traditional auto engine is successful, this engine will meet stringent future standards by use of "second generation" catalytic converter systems and better air/fuel ratio controls, using either an advanced carburetor or electronic fuel injection. Two systems are being developed to reduce NO_x emissions to statutory levels (0.4 grams per mile): 1.) a dual-converter system in which NO_x reduction and HC-CO oxidation take place sequentially in two converters in series; and 2.) a 3-way converter in which all three pollutants are controlled within one unit.

The primary emission control device before combustion is any one of several devices that improve control of the air/fuel mixture thereby attaining more complete burning. Included in means to achieve a more suitable combustion mixture are improved carburetors, pre-vaporization devices, and fuel injection systems.

Conversion to other engines may call for control of other pollutants by other devices. In particular, while the diesel emissions of CO and HC do not require emission controls, NO_x is a major problem and widespread use of diesel autos could lead to new emission controls on SO_x, odors and particulates.

Ability of Engines to Meet Emission Controls. Of the four engine types forecast as plausible candidates for 1980-1990, the traditional and diesel have serious emission control problems, while the gas turbine and Stirling (both in the experimental stage of development) appear to have no major emission constraints. The traditional engine with currently available emission control systems does not meet statutory requirements.

The most immediate alternate engine, the diesel, provides some solution to the problems most amendable to solution, but it also involves numerous new uncertainties. According to JPL, the diesel engine can just meet an NO_x standard of 1.0-1.5 grams/mile, but cannot meet 0.4 g/m. There are potential new problem areas -- the uncertainties of higher SO_x, particulate and odor emissions. Particulates and odor are a function primarily of the combustion process, and retreatment of the fuel to remove sulfur impurities is a possibility.

The gas turbine and Stirling engines produce less emissions of HC and Co because hey are continuous combustion engines. Forecasted emission rates for the Stirling engine without controls appear to be less than half the legislated standard. New pollutants may become a problem due to the different fuels that these engines can burn. In view of emission levels forecast for these engines they will probably require no emission control devices other than control of air/fuel mixtures.

Generally, then, for air pollutant emissions - as for fuel economy - the gas turbine and Stirling engines will clearly be the best choices when they are available, provided their R&D promise holds up.

At present EPA, operating under authority of the Clean Air Act of 1970, enforces compliance with emission standards by testing prototype vehicles from each engine family produced. The initial prototype for each engine family is tested for a simulated 50,000 miles and a deterioration factor is derived. A specified number of additional prototypes of each engine family is tested through 4,000 miles and the derived deterioration factor is applied to determine performance at 50,000 miles. All prototype vehicles must meet the mandated standards.

Proposed amendments to the Clean Air Act of 1970 would apply testing to a specified number of vehicles from each engine family selected at random from the production line. Of this specified number of randomly selected vehicles, 60 percent must meet the mandated standards or EPA could suspend or revoke certification of that model until the manufacturer could show that the problem had been corrected.

Noise Pollution. The primary noise sources in a 1975 auto are exhaust (up to speeds of 35/45 mph) and tires. With the reduction of engine size plus new types of engines, the engines may become another noise contributor.

Based on studies of noise and community reaction, an outdoor day/night sound level of 60 decibles (db) causes complaints from less than 2 percent of the households. The TF-80 report estimates 62 million people of the nation's 215 million would be subjected to 60 db and less than 28 million subjected to 65 db. EPA has proposed, as a goal, a national outdoor level be 55 db; presently 98 million people are exposed to this level or higher.

The realization of this goal is conjectural since bald tires at 35mph cause 56-58 db. While the urban traffic is often below 35 mph, it is accompanied by increased noise of acceleration and stopping and exhaust noises. Even when engine and exhaust noises are reduced, tire noise is likely to remain at present levels due to tread/safety considerations.

Modifications to the traditional engine will not cause any increase in noise although the use of a smaller engine in the auto may cause some increase, but this is controllable by present technology.

The diesel engine is somewhat louder and will require more exhaust baffling. The Stirling engine should be a major improvement over current engine noise levels. The gas turbine may produce a new problem of a different, more objectionable, sound that will require better baffling of the engine compartment.

Safety Considerations. The safety considerations for the intermediate period and post-1980 period auto concern reduction of personal injury exposure and vehicle

damage. While vehicles include many safety devices, still other means of safety improvement are possible through changes in the operating environment. These extra-vehicle provisions include enforced speed limits and reduction of roadway hazards.

While introduction of the Stirling and gas turbine engines may entail some new forms of hazard, the basic configuration and components are such that no new significant hazard levels are known to be added. Therefore, the discussion here deals with structural and non-engine components of future model year autos.

Categories of Safety Measures. Elements of safety measures can be grouped into three categories; crash-avoidance measures, crash worthiness steps to reduce personal injury and vehicle-damage limiters.

Crash-avoidance measures include improved braking systems, better lighting and fields of view (direct and indirect) and impaired (intoxicated) driver interlock systems. Besides the vehicle, a number of highway-roadway changes are also possible to reduce the incidence of accidents through removal or modification of barriers and better visibility conditions.

Crashworthiness to reduce incidence and level of personal injury includes structural design to lower the level of penetration of barriers, design of engine deflection routes, personal restraint systems (both belts and passive devices), and design of fuel system safety features. External to the vehicle, safety measures include design of barrier elements along the road that will either break away easily or will offer a more flexible barrier.

Vehicle damage criteria involve the reduction of the level of repair costs and the level of damage to safety systems. External measures are the same as those noted above in connection with crashworthiness.

Intermediate Period Improvements. Prior to the 1980 model year, likely crash avoidance improvements beyond the features of the 1975 model year will include changes to braking systems, lighting and fields of view. Implementation of Federal Motor Vehicle Safety Standard (FMVSS) 105a will lead to better braking systems to reduce stopping distances and a reduction in required brake pedal forces. Additional intermediate term brake improvement may include controlled lock-up (actually anti-lockup) as this will permit shorter stops on wet and icy pavements (up to 10-15 percent) and better vehicle stability during the braking period.

Vehicle lighting changes are being considered that would allow increasing the candlepower of headlights and introduction of a 3-beam (low, mid and high) lighting system. Additional minor modification to the rear lights to allow separate stop-lights and tail-lights are also being considered.

Mandatory improvements in the fields of view proposed are compatible with other expected vehicle structural changes modifying vision and include light transmission and reflection performance specifications, better sun visors, reduction of obstructions, (interior rear view mirror location) and better rear view mirror systems. Further safety features for mirrors and other external devices will probably be breakaway subsystems to reduce pedestrian injury hazards. With the exception of the anti-lockup brake systems, all of these features are attainable with today's technology.

Personal injury crashworthiness is normally categorized as front protection, side protection, rear protection, roll-over protection and fire protection. In addition to 1975 requirements, one additional requirement limits intrusion of vehicle parts through the

windshield. Other plausible safety features for the intermediate period include passive personal restraint devices for up to a 40 mph barrier impact plus upgraded protection from vehicle side impacts.

The principal vehicle damage limiting devices will be continued bumper system refinements, and particularly the introduction of lighter weight systems through use of high strength low alloy (HSLA) steel and plastics.

Post-1980 Vehicle Safety Improvements. Advanced crash avoidance systems that could be developed for the 1980's period fall into three categories: advanced braking, advanced lighting and impaired (intoxicated) driver-interlock systems.

In the category of braking systems, a family of improvements is plausible, ranging from warning systems of possible obstacles to automated systems that actually brake the vehicle if the driver fails to respond. Additional brake improvements may include little or no maintenance systems - the so -called lifetime brakes.

Advanced lighting systems to be considered beyond 1980 may center on reduced glare, automatic dimmers and beam aiming systems, or polarized light.

Since alcohol and other driver-impairing drugs are a factor in many accidents, further development of systems requiring the operator to pass a test prior to operation are likely to be suggested for post-1980 vehicles.

Advanced crashworthiness research will continue in the areas of front and side impact protection. Additional studies should include the trade-off between ejection control and escape capabilities from a damaged vehicle.

CHAPTER VI

ALTERNATE MATERIALS AND FUELS

This chapter evaluates the potential availability and relative costs of traditional and novel materials and fuels for automobiles in the United States.

The materials section discusses material availabilities and accompanying economic factors which could affect the design and manufacture of automobiles. The materials analysis considers (1) the character of motor vehicle basic material demand, (2) the growth of materials production capacities beyond 1980, (3) a consideration of the economic factors which could affect materials costs, and (4) an evaluation of the availability of some specific materials used in new automobile designs and structures.

Increased use of alternate and substitute materials advance the goals of increased fuel economy, safety and emission control. Substantial amounts of aluminum, plastics and lightweight-high strength low alloy (HSLA) steels are expected to be introduced before 1985. Recent design changes illustrate a trend toward these lighter, more cost-effective materials in the automobile.

The fuels section (1) discusses the physical and institutional factors which affect the use of current and novel fuels, (2) identifies and evaluates alternative fuels such as methanol and diesel, (3) evaluates the availability and cost of the "conventional" refinery products, i.e., standard, no-lead, and premium gasolines, based on various economic and technological factors, and (4) evaluates the financial effect on the refining industry of changes to alternate fuels.

The fuel requirements of current automobiles and alternate engines under consideration ensure that conventional liquid hydrocarbon fuels of the type generally derived from petroleum will continue to be used in large quantity in the next 15-20 years. After 1990, it is possible that synthetic liquid fuels derived from coal and shale oil could supplement diminishing supplies of petroleum, assuming the necessary investment and technical commitments are made today.

Materials

This portion of the report analyzes a variety of feasible changes in materials uses that are coincidental with changes in automobile design to meet the national goals of materials and energy conservation, pollution abatement, and safety on the highways. The

introduction of properly engineered materials into the automobile can make significant contributions towards advancing these important, but often conflicting goals. The development of economical applications of light, inexpensive, and strong materials such as aluminum, plastics and high-strength low-alloy steels could advance both the goals of conservation and pollution abatement while still ensuring the safety and comfort of the automobile.

As is almost always the case, the choice of materials for use in the automobile will be a compromise between the properties of the materials and their relative cost. The most effective material, with best performance, in processing and final product, is sometimes expensive or unavailable. On the other hand, less effective materials are often widely available and entail less expense.

Economic and Technological Factors in Material Selection. In practice, every one of the approximately 15,000 parts in an automobile are evaluated and selected on the basis of analysis which weighs the technical tradeoffs among such factors as part size and shape, material strength, machineability, malleability, availability, and relative cost.

The automobile industry has demonstrated remarkable ingenuity in the selection and use of materials in both the vehicle body and engine. During the period 1925-1975, the average family automobile has almost doubled in weight from 2400 to over 4000 pounds. During the same period the automobile quadrupled in performance from 35 horse power to 150 horsepower.[1/] Comparable estimates of average automobile costs for the period show how successful the automobile industry has been in controlling materials input costs. In 1925, the average cost of materials in the automobile was $.088 per pound of automobile (constant 1958 values) and by 1975 material costs had only risen to $.091 per pound. Compared to a measure of performance, the materials cost decreased substantially in constant 1958 values from $6.30 per horsepower delivered in 1925 to $2.50 in 1975. The following table shows materials used in a typical automobile in 1925, 1940 and 1975.

1/ Figures are average estimates representing typical four-door six-passenger sedans produced for most of the fifty-year period. Derived from data in Automotive News.

Materials Used in the Automobile [1/]

	1925 (Percent)	1940 (Percent)	1975 (Percent)
Total	100.0	100.0	100.0
Iron	14.1	17.3	16.3
Steel	68.7	67.0	58.0
Carbon	60.6	61.2	55.0
Alloy & Stainless	8.1	5.8	3.0
Aluminum	0.4	0.3	1.9
Zinc	0.6	0.5	1.6
Copper	1.0	1.0	0.6
Lead	1.0	1.0	0.6
Glass	1.8	2.2	2.3
Rubber	2.6	2.2	5.0
Plastics	--	--	3.1
Soft trim	4.9	3.9	4.8
Paint	0.9	0.6	0.6
Fluids	4.0	4.0	5.2

1/ Automobile is a composite of typical four-door, six-passenger sedans produced for most of the fifty-year period.

-- Denotes zero or negligible

Source: Wards Automotive Reports and Motor Vehicle Manufacturers Association.

The relative use of materials such as iron, carbon steels, copper, lead, zinc, glass, fluids, soft trim have changed only slightly. Materials such as aluminum, plastics and rubber have increased substantially while alloy and stainless steels have decreased from 8 percent of automobile weight in 1925 to 3 percent in 1975.

An important determinant in the selection of materials has been the relative cost of inputs. However, several developments during the 1960's and 1970's have changed the weighting of factors which influence the selection of automobile materials. During the 1960's safety and air pollution control regulations and increased purchases of optional equipment, such as air conditioning and automatic transmissions required the use of more and different materials and added both weight and cost to the automobile. The increased weight plus the loss of fuel efficiency due to air pollution controls contributed significantly to the decrease in fleet fuel economy during this period. The recent trend in fuel prices and coincidental need for energy conservation signals the need for a major change in materials for automobiles.

Lighter and smaller automobiles offer the possibility of increased fuel economy. Weight reductions of 500 to 1000 pounds per car might improve average fleet fuel economy by 6 to 25 percent depending on such fleet characteristics as the initial automobile poundage, size of engine, and weight distribution. Weight reduction is not the only way to improve fuel economy while attempting

to meet other health or safety standards. New engines and transmissions offer other opportunities for increased fuel economy, but require the introduction of new materials and the development of new technologies in order to apply them economically.

The selection of alternate and substitute materials in the automobile may simultaneously advance the goals of increased fuel economy, safety, and emission control while maintaining performance standards in the automobile model types. The following analysis evaluates the most likely materials substitutions and applications which would aid in fuel economy through reduction in vehicle body weight, i.e., aluminum, plastics, and high-strength low-alloy steels (HSLA). Additionally, it examines the availability and costs of materials which would aid the economic introduction of new automobile engine technologies such as Stirling and Brayton engines.

<u>Growth of Materials Markets Beyond 1980</u>. The cost and availability of materials for the automobile industry depend upon a multitude of factors. It is clear that material supplies in general depend on potential demand for each material, trends in capacity of the material producers, and the availability of basic raw materials. Material supplies and prices to the automobile industry

in particular, not only depend on the automobile industry's technical and engineering plans for materials use, but also competitive demands for the same materials from other sectors of the economy.

The figures in the following table show the "normal" annual growth rates anticipated for the domestic supply of materials during the period 1975-1995. For comparison with these figures, the growth rate of the automobile industry is shown on the bottom line. These figures reflect long-term growth rate estimates and are based on historical performance of these industries over long periods of "normal" production. The estimates are generally considered conservative, reflecting the uncertainties of capacity expansion during periods of inflation, reduced demand, and possible capital shortages.

Material Supply Growth Rates (1975-1995)[1/]
(Anticipated Annual Compound Growth Rate)

Materials		1975-1980 (Percent)	1981-1995 (Percent)
Iron castings		3.0	3.0
Steels:	Carbon	3.0	3.0
	Galvanized	2.5	2.5
	Aluminized	2.5	2.5
	Stainless	5.0	4.0
	Alloy	6.0	3.0
Aluminum		6.0	6.0
Lead		4.0	4.5
Copper		4.3	4.5
Zinc		3.0	3.0
Nickel		5.0	5.0
Chromium		2.9	2.9
Molybdenum		4.0	4.0
Manganese		2.3	2.3
Synthetic rubber		7.5	5.0
Plastics		8.7	8.0
Glass		9.0	3.0
Automobile		4.0	2.5

1/ BDC, U.S. Industrial Outlook, 1975; BOM, Minerals Yearbook, 1972, 1973, and 1974 (preliminary); U.S. Department of Commerce, Projects Independence: Availabilities, Requirements, and Constraints on Materials, Equipment, and Construction, 1974.

A comparison of the automobile industry growth rate with materials growth rates seems to indicate that all the major traditional automotive materials will generally be in sufficient supply during the entire period. This condition, of course presumes that traditional supplier/consumer relationships are sustained,

and production is continued without interruptions caused by material ore shortages, import embargoes, or other critical material input disruptions.

In the case of aluminum, however, the historical rate of growth of 8 to 10 percent per annum in the U. S. is expected to decline to about 6 percent during the next ten years. Future expansion of primary aluminum capacity in the U. S. may be limited due to the unavailability of cheap power sources. However, U. S. primary aluminum producers may increase their investment in new capacity in areas outside the U.S. where reasonably-priced power is available.

Most automobile-related materials demands are generally characterized as "derived" demands. Historically, the relationship between the automobile industry and its materials suppliers has been demonstrated to be closely cooperative in regard to engineering and specifications. The development of many present materials and material-producing processes were induced by the materials demands of the automobile industry. High-strength carbon steels, mass-produced flat glass, synthetic rubber and many other materials were developed, either indirectly, or directly, in response to a perceived demand in the automobile industry. These strong historical relationships between suppliers and purchasers

in the automobile industry demonstrate a significant factor bearing on the general availability of materials to the automobile industry. The demand table below indicates the relative significance of automobile material consumption in the United States during 1973-1975. It is likely that these relative levels of consumption will persist into the future for each material with the possible exception of certain types of steel, aluminum, plastics, platinum and rhodium.

Other industrial demands are having significant effect on aluminum and steels, particularly alloy and stainless steels. The primary aluminum industry is currently experiencing substantial growth in metal container demand. Metal can and container demand for aluminum has expanded at an annual growth rate of over 10 percent for the past several years. While this growth does not indicate that the aluminum industry would be unable to meet increased long-term automobile demands for aluminum, it does signify a possible constraint on any significant short-term increase in aluminum supplies for the automobile industry.

Similarly, the steel industry is currently undergoing a transitional period where shifts in the traditional steel market patterns are discernible. The demand for steels, particularly alloyed and stainless,

by the energy-production industry since 1973, coupled with the coincident decline in automobile-related steel demand may signify a new long-term shift in the steel industry's major markets. This condition could have major consequences for automobile industry steel purchasing patterns. At least, this condition signifies new competition among all buyers of both carbon and alloy steel materials.

Automotive Materials Demands 1973-1975
(Annual Average)

	Materials Usage by Automotive Industry (Thousands short tons)	Automotive Consumption As percent of Total U.S. Materials Consumption (Percent)
Gray iron	1,300	13.8
Malleable iron	300	43.0
Carbon steel	3,200	8.5
Alloy steel	500	5.0
Stainless steel	75	5.9
Aluminum	350	6.1
Zinc	145	10.0
Copper	100	3.7
Lead	150	9.1
Rubber	850	31.5
Glass	410	5.0
Plastics	600	4.0

Source: U. S. Department of Commerce, U. S. Industrial Outlook 1976. 1974/75 Automotive Facts and Figures, 1976, and U.S. Bureau of Mines, Minerals Yearbook.

Material Prices to the Automobile Manufacturers. The previous consideration of the "normal" growth of supplies of materials indicated that there should be no long-term pressure on supplies for any material in the automobile which would cause an extraordinary rise in the producer's selling price of material products relative to alternative materials given the assumed growth rate. This does not imply that "normal" production processes could not be disrupted by extraordinary developments in materials markets in the future. Embargoes, cartels, work stoppages, and capacity shortages all present potential short and long-term sources of disruption that could modify availability and price of specific materials.

For example, it appears that supplies of stainless and alloy steels will experience persistent pressure due to raw materials constraints as well as rapidly growing demands for these metals in energy production and other areas. In addition, aluminum and plastics require relatively large amounts of fossil fuels for processing. Producers will continue to pass through increases in input costs which may not be proportionate with other materials used in the automobile.

Fortuitous and/or hard-won innovations in the recovery of resources, development of products, and use of production factors including energy may counteract some or all of the adverse effects in the long run, with the adjustments affecting the materials mix of the automobile.

The following table indicates the relative prices to the automobile manufacturer of most materials in the current automobile. A relative price for plastics is not included since there is no "typical" plastic used in the automobile. The range of prices for plastics and molding resins in 1974 was from $.30/lb. to $1.70/lb. Until recently, the relative price levels of materials to the automobile manufacturers was a major determinant in the material usage in the automobile. Guided by cost/performance criteria, steel and non-ferrous metals were routinely designed into automobiles rather than more expensive substitutes.

Such economic factors as import dependencies, material recycling, and raw materials shortages have crucial bearing on the relative level of material costs and availability.

Average Material Price to the Automobile Manufacturer (1974) 1/

Material	Price Range Dollars per pound 2/	Material Price per pound Relative to Automobile Average Price per Pound 3/
Cast iron	.20-.25	1.38
Carbon steel	.10-.15	.75
Alloy steel	.25-.30	1.69
Stainless steel	.50-.60	3.44
Aluminized steel	.20-.25	1.38
Galvanized steel	.20-.25	1.38
Aluminum	.30-.35	2.00
Lead	.25-.30	1.69
Copper	.50-.60	3.44
Zinc	.35-.40	2.31

1/ Selected issues of American Metal Market, 1974.

2/ Prices are ingot prices and do not include a premium for special shapes.

3/ Average material price for auto in 1974 was 16 cents per pound.

The following table shows the U. S. import dependencies for materials used in the manufacture of automobiles relative to total shipments of materials in the U. S. market. It shows import dependencies are not substantial in the case of carbon steels, iron, lead, and molybdenum. However, the current U.S. dependency on imports of bauxite, alumina, zinc, petroleum, and raw alloy metals which go into the manufacture of stainless and alloy steels is relatively high.

U. S. Materials Import Dependency
1968-1975

Material	Import Dependence 1/
Manganese	1.00
Chromium	1.00
Cobalt	1.00
Columbium	1.00
Platinum group	1.00
Nickel	.94
Alumina and bauxite	.90
Vanadium	.60
Tungsten	.55
Zinc	.45
Copper	.34
Petroleum	.30
Lead	.24
Iron ore	.21
Aluminum	.15
Cast iron	.01
Molybdenum	0

1/ Imports as ratio of total shipments. Data derived from the Bureau of Mines' *Minerals Yearbook.*

Supply problems for the automobile industry, as for any U. S. industry, could materialize if the foreign producers form an effective cartel for the materials. However, this would require several conditions set out below which are not likely to occur at the same time:

(1) The economic and political interests of producing and consuming nations must be sufficiently divergent before the formation of a cartel is feasible.

(2) The economic and political gains to producing members must be sufficient to prevent price cutting or re-exporting within the cartel.

(3) The number of potential producing nations is limited and they share a strong common bond.

(4) No easy substitutes for the material can be available to consuming nations.

(5) Consuming nations have no economically accessible reserves or stockpiles upon which to rely.

Recent experience indicates that petroleum-producing and exporting nations have been able to maintain these pre-requisites for a successful cartel.

Zinc production in the United States has fallen continually over the last few years. Capacity expansion for zinc production in the U.S. has been curtailed. Similarly, the possibility of adverse action by the bauxite cartel, while being threatened, seems unlikely. The commonality of economic interests in the producing nations does not appear sufficient to assure market control. Even assuming some market control, the

effect probably would be on price rather than availability. The possibility of recovery of aluminum from non-bauxitic sources, such as alunite, anorthosite, and clay would place a practical limit on the price charged for bauxite or alumina, although the substitutes are more costly.

With the exception of molybdenum, most alloying metals used in the production of alloy and stainless steels are imported in whole or in part. A significant trend toward designing these metals into the automobile might raise material costs and increase industrial dependency on foreign imports. This could lay the foundation for cartel attempts in one or more of the alloy materials.

Private and government material stockpiles, advances in technologies which develop more economical material substitutes, and automobile design changes might in the long-term accommodate most of those potential problems associated with dependence on foreign sources for certain materials. However, in the short-term, U. S. automobile production is dependent on a continual and assured supply of imported materials. Alloying metals such as manganese, cobalt, and columbium are critical to the stainless and alloyed steels used by the automobile industry. An interruption of imports of these materials might have a

severe short-term effect on the automobile production process unless alleviated by the protective use of private and government materials stockpiles and positive government action.

The recovery of energy embodied in recycled materials also results in cost savings. For example, it has been estimated that the recycling of steel scrap typically results in an average net energy saving of 13 million BTU's per ton of steel produced. Copper and copper alloy scrap recycling results in an average saving of 50 million BTU's per ton of copper produced; and aluminum recycling results in an average saving of 172 million BTU's per ton.[2/]

The recycling table, following, indicates the average relative importance of recycled materials to the total shipments of materials during the period 1970-1975. These categories of scrap include prompt industrial (new scrap) and dormant scrap (old scrap), but exclude home scrap. Most metal industries are effective in utilizing scrap materials with scrap recycling inputs representing between 20 and 50 percent of the total shipments. These recycling ratios are typical of the present condition of resource recovery of metals. Some materials have a higher recovery potential should future metal demands shift.

2/ Vogley, W.A., et al, Mineral Facts and Problems, 1970, U.S. Department of Interior, Bureau of Mines, Washington.

The purity of the recycled material may cause restrictions in use. For example, recovered aluminum generally has sufficient impurities remaining after recovery to restrict its use to castings. The materials which experience the lowest relative level of recovery are the alloy steels. This is attributable in part to the difficulty of separating and segregating alloy steel scrap by alloy type.

<u>Recycling of Materials (1970-75)</u> 1/
(Annual Average)

	New scrap	Old scrap	Annual Average Recycling ratio 2/
	(Thousands of tons)		
Cast iron	3,000	4,000	0.47
Carbon steel	12,000	27,000	0.43
Stainless steel	200	250	0.33
Alloy steel	200	400	0.07
Aluminum	965	265	0.21
Zinc	216	53	0.17
Copper	843	458	0.35
Lead	160	655	0.54
Nickel	5	36	0.26

1/ Recovered Metal Basis.

2/ Ratio of new and old scrap to total shipments.

Note: Figures derived from the Bureau of Mines' *Mineral Yearbook.*

Greater use of aluminum can occur in both the engine and the rest of the vehicle. Increased use of aluminum engine components will place demands on the castings portion of the industry which relies heavily upon secondary recovery of aluminum. Although a threefold increase in the use of aluminum in the automobile above the present level of about 100 pounds per unit would be substantial, it should be attainable through more efficient scrap recycling and some expansion of primary capacity. The use of primary sheet aluminum in the body of the automobile requires increased primary smelting and rolling mill capacity.

Aluminum use in the automobile has been primarily in die-cast parts. It has been estimated that the use of aluminum as a substitute for ferrous metals offers a potential weight saving of as much as 40-50 percent of original weight of the automobile part. Aluminum also offers the advantage of being somewhat compatible with current automobile tooling machines and is recyclable. However, aluminum is still less formable and weldable than steel and is less heat-resistant in the engine than ferrous castings.

Another major area which represents a potential influence on the normal availability and prices of materials for the automobile industry is that of recurring raw materials shortages.The economic experience of the early

1970's demonstrates that raw materials shortages can occur and persist in the United States even without the adverse effects of economic controls. Examination of trends in the supply and demand of materials indicate that the pressure on existing supplies and capacities caused by the extraordinary inflationary surge of 1971-1973 and the ensuing economic controls were an apparent anomaly in the materials markets. A combination of economic factors such as inflation, sustained international economic growth, increased interdependencies of nations, and the necessity for increased prices to finance capacity expansions caused temporary imbalances in an otherwise adequate growth of raw material supplies. With respect to long-term availabilities, there is evidence that the supply of material ores in the earth's crust is sufficient to meet the world's needs for nearly every material well beyond 2000.[3/] In addition, it appears that production economies, the development of substitutes, new technologies, increased recycling and the exploitation of new mineral deposits or previously uneconomical deposits could meet material demands over a longer time period. However, there are still persistent problems of unbalanced growth in selected materials. These will cause short-term shortages and price increases. The solution appears to be recognizing the growing interdependencies of demands and the need for planning.

Current Materials Usage. Recent automobile design changes illustrate a trend toward lighter and more cost-effective materials in the automobile. Materials such as aluminum and plastics have been increasing considerably as substitutes for iron castings, rolled and strip steel, zinc castings, and glass. High-strength low-alloy steel has been considered and been used to some extent as an alternative to conventional mild steel. In addition, emissions control regulations have increased the need for platinum group metals and stainless steels used in today's typical catalytic converter.

Future Changes in Materials Usage. Several material substitutions are feasible in the automobile which would contribute to the achievement of national goals such as fuel economy, safety, and emissions control. A significant degree of materials substitution is now taking place in conjunction with advances in body and chassis design as part of the industry's current vehicle down-sizing programs. Substantially greater amounts of aluminum, plastics, and lightweight, high strength, low alloy (HSLA) steels are expected to be used by 1985. The timing of these materials substitutions is conditioned by major factors in the automobile industry.

3/ U.S. Department of Commerce, Bureau of Domestic Commerce, U.S. Industrial Outlook, 1976.

First, the automobile industry is reluctant to make a commitment to a novel material for a particular application or part until considerable test and production experience exists. Thus, three to five years may elapse between the testing and mass production of parts using new materials. Second, a substantial amount of research and development must be applied to performance and processing technology before some materials can be seriously considered for use in the automobile. Issues such as the formability and weldability of aluminum, the malleability of HSLA, the strength of plastics must be examined and resolved before large production runs are undertaken.

The possibility of extensive plastics substitutions in the automobile will be restricted by raw material availability constraints and costs. The input cost for petrochemical feedstocks will continue to climb as oil prices are decontrolled. In addition, the slow speed at which alternative fuels are developed puts increasing pressure on available supplies, capacities, and prices of petroleum-based fuels and feedstocks. If this problem becomes less significant, estimates are that as much as an additional 300 pounds per unit of

plastics could be supplied as substitutions for steel, zinc castings, interior and metal trim. The cost effectiveness of these substitutions will have to be evaluated individually by the automobile industry for each specific application.

Plastics and resins offer two distinct advantages over most materials, relatively low cost and material formability. In addition, most exterior plastic components offer a weight saving of from 35 percent to 50 percent compared to similar steel products. However, automobile plastics tooling machines would require considerable additional investments by the automobile industry since most metal-forming machines are not adaptable to plastics. Plastics also present formidable recycling problems.

Increased use of high-strength, low-alloy steel is being actively pursued by the automobile industry as a weight reduction method to improve automobile fuel economy. The long-run supply situation appears to be adequate. However, in the short-run, the increased demand by the automotive sector may put strains on supplier capacities. This is due to the dependency on imported alloying metals, the lead time required to build new mills and the current low recycling rate of HSLA steel.

Weight savings in automobile applications of HSLA steel are in the range of 30-35 percent compared to mild steels. This is not as much as aluminum or plastic parts. However, HSLA offers some advantages in the strength-weight ratio, performance, machine-ability and weldability compared to these lighter competitors. Presently, HSLA steels are 40 percent more expensive than carbon steels and costs must be reduced before large amounts of HSLA steels will be substituted for carbon steel. However, growth in HSLA steel use in the automobile has been impressive. In 1972 the average vehicle contained around 30 pounds, in 1973 over 60. It is entirely possible that by 1985 over 250 pounds of HSLA steel per automobile could be used as a substitute for 1010-carbon steel.

Platinum group or noble metals (platinum, palladium, rhodium, ruthenium) are used in present (1975/1976 oxidation catalysts.[4/] Currently, average total noble

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4/ Hightower, Joseph W., et al. An Evaluation of Catalytic Converters for Control of Automobile Exhaust Pollutants. Consultant Report to the Committee on Motor Vehicle Emissions, Commission on Sociotechnical Systems, National Research Council. Washington: National Academy of Sciences, 1975. U.S. Environmental Protection Agency. Emission Control Technology Division, Automobile Emission Control - Technical Status and Outlook as of December 1974. Washington: U.S. Environmental Protection Agency, 1975.

metal requirements are about 0.05 troy ounces per unit with the most prevalent composition being 71 percent platinum/29 palladium by weight. Provisions for adequate supplies of these catalysts have been made by the automobile industry through long-term procurement contracts.

If the statutory NO_x level of 0.4 grams/mile is imposed and if catalyst technology is used to meet this requirement, it could result in additional demands for noble metals. It is impossible to predict with certainty the type of catalyst system (3-way or dual) that will be selected, the compositions of the noble metal formulations, or even if the catalyst system ultimately produced will be of a noble metal or the base metal configuration. Assuming the use of a noble metal catalyst, (the more critical metal requirement) it has been estimated that as much as double the current level of noble metal could be required resulting in 0.10 troy ounces per unit. Imported materials can be supplied given a suitable lead time and the continued willingness of the automobile industry to enter into long-term procurements contracts. World noble metal reserves and resources are more than adequate to support the increased production in most cases. Platinum

group metals are stockpiled and are currently in relative abundance due to reduced automotive demand in 1975. An effective cartel in noble metals is unlikely for reasons discussed earlier. However, development work with catalytic converters is progressing to the extent that individuals close to the research believe it is reasonable to expect that a three-way catalyst will use 0.026 troy ounces of platinum and 0.011 troy ounces of rhodium for typical small four cylinder gasoline engine applications. Researchers also indicate that it is not likely that suppliers of these noble metals will find it possible to produce and process a sufficient quantity of rhodium to satisfy expected demand. If rhodium must be used for all 1979 and later models (for (NO_x emission control) the additional demand would represent about 100 percent increase over currently projected production. Since rhodium occurs in a ratio of one to eighteen parts of platinum in the ore it is not likely that rhodium production will be increased to the extent required.

Catalyst technology for statutory NO_x control can also affect stainless steel requirements for housings and exhaust pipes. Assuming that Type 409 stainless

will continue to be used for these applications, its use in U.S. automotive catalysts could be increased somewhat less than double the current amount depending on the system chosen and the packaging efficiency. The effect of this on chromium is to increase its usage by less than 1 percent of current world consumption.

A recent JPL report[5/] estimated that the introduction of a metallic Stirling or Brayton engine (except for ceramic Stirling air preheaters and Brayton regenerators) in the 1980's would have the effect of increasing the consumption of stainless steels and requiring the introduction of significant amounts of superalloys for automotive industry consumption.

The ability to undertake substantial redesign of automobiles in regard to materials requires a coincident effort to coordinate supplies of materials in the quality and quantity needed for the economic production of efficient automobiles. This analysis of both current and potential future automobile designs

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5/ Jet Propulsion Laboratory, Should We Have A New Engine? An Automobile Power Systems Evaluation, SP 43-17, two volumes, August 1975.

considers the timing, level of investment, and availability of capital to undertake the investment.

Fuels

The relationship between the present spark-ignited internal combustion automobile engine and the availability of compatible fuels reflects a long-standing systemic relationship between automotive manufacturers and the energy-producing sector of the economy. Such physical and chemical properties as volatility, toxicity, corrosiveness, octane and cetane numbers, specific gravity, energy content, and sulfur content all bear directly on the selection of fuels for use in the typical automobile engine. Many of the same considerations would bear on the selection of fuels for alternate automobile engines such as diesels, turbines, and Stirling cycle engines.

The possibilities for implementing significant changes in the fuel mix of the U.S. automobile fleet in the short term are poor in view of the substantial investment and institutional infrastructure developed to support carbureted engines and gasoline distribution. Conversion of the automobile fuel-producing and distribution system from fuels servicing present gasoline engines to fuel-injection, diesel engines or Brayton, Stirling,

and Rankine-cycle engines would require extensive planning and long lead times. Environmental considerations may also have great bearing on the refining industry product slate (the typical mix of fuels produced by the refining industry) and the relative availability and the cost of automobile fuel. The most significant potential issue is the desulfurization of gasoline at the refinery. Some recent experiments indicate strongly that desulfurization of gasoline may not be necessary. This issue could become more significant if automobiles must use higher boiling point fuels such as diesel fuel which contains more sulfur than gasoline and thus may be more costly and difficult to desulfurize. Most estimates of the cost of a major refinery program to desulfurize gasoline indicate an additional cost to customers of fuel at the pump of 1 to 1-1/2 cents per gallon. It may require between six and fifteen years to achieve.

Alternate Fuels. Several novel alternative fuel types have been suggested for use in automobile engines. Methanol, ethanol, hydrogen, ammonia, acetylene, ethers, and hydrazine have been suggested as being compatible with efficiencies and systematic characteristics of the United States transportation system. Investigation and evaluation indicate that none of these can be used alone successfully in current or anticipated automotive

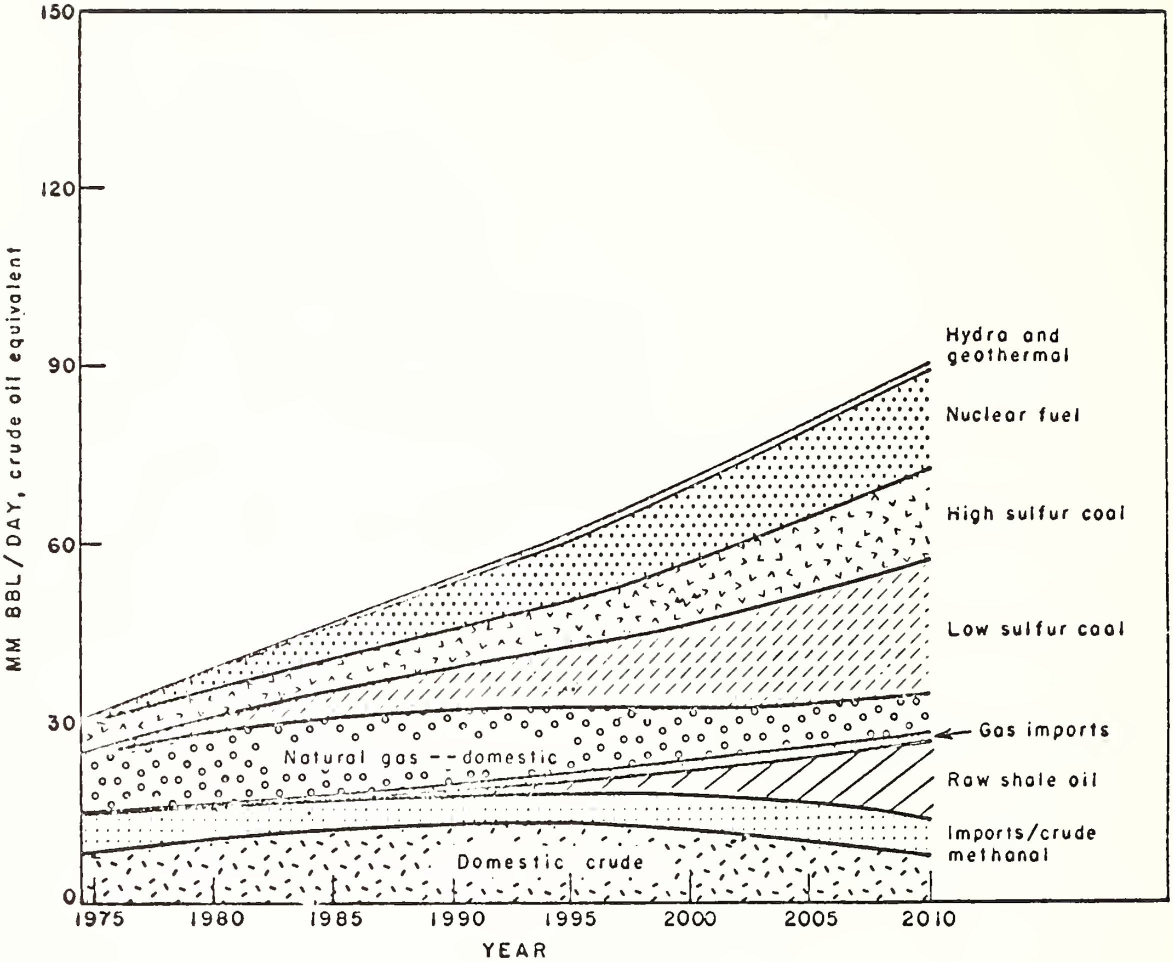
engines and fuel distribution systems. Methanol blended with gasoline, however, appears to have promise. Liquid hydrocarbons derived from coal and oil shale also have possibilities as future alternative automotive fuels.

The fuel requirements of current automobiles and alternate engines under consideration ensure that conventional liquid hydrocarbon fuels of the type generally derived from petroleum will continue to be used in large quantity in the next 15-20 years. Such supplemental sources as liquified coal and shale oil will probably be developed in a manner which will assure maximum substitutability for present petroleum-based fuels.

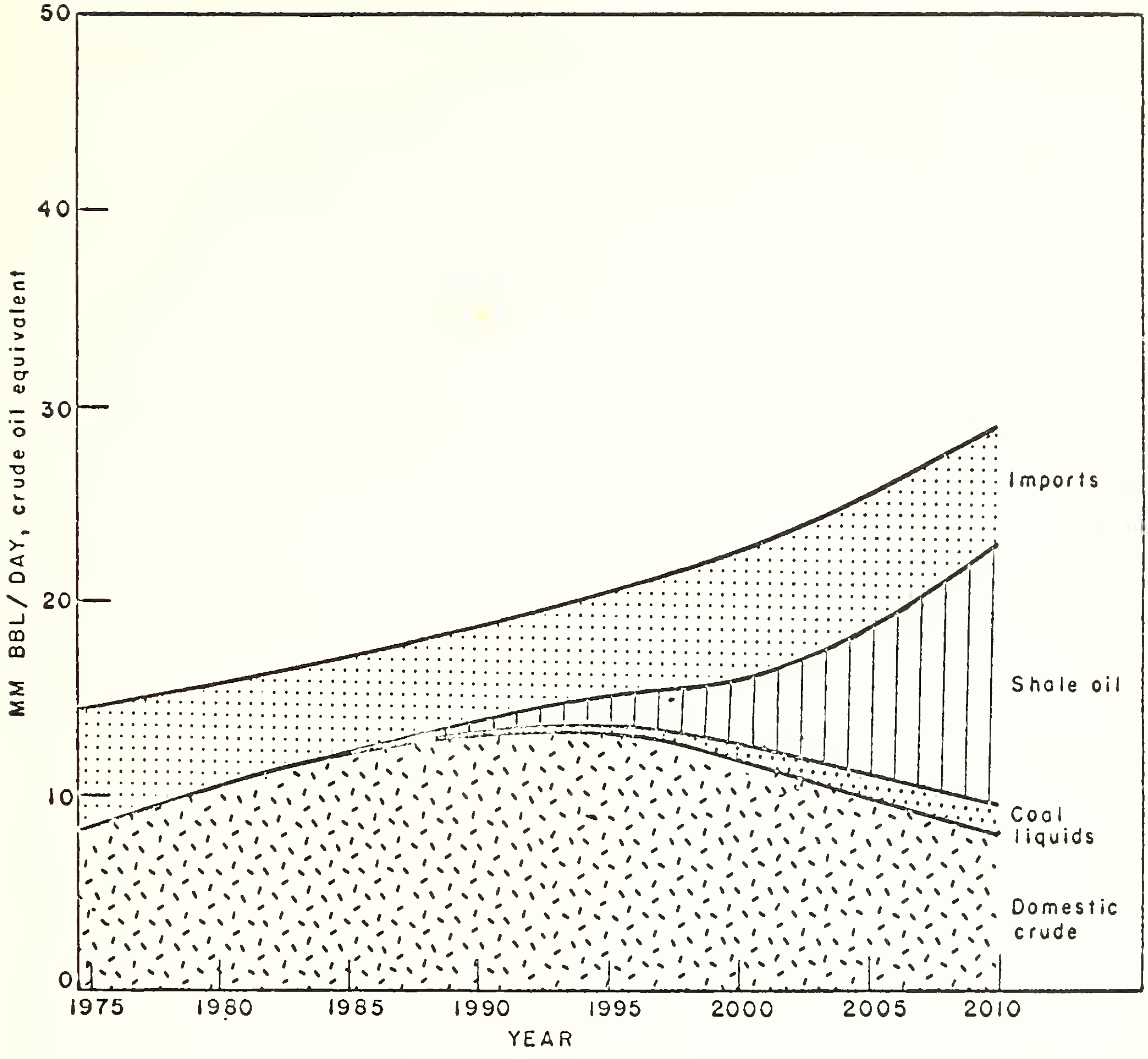
The principal types of petroleum-based fuels are gasoline, diesel or middle-distillates and broadcuts. Broadcut is produced from the upper 85 percent of a barrel of natural crude oil and present refinery technology is sufficiently advanced for broadcut production. Broadcut cannot be used with carbureted, spark ignition engines and, therefore, cannot be considered to be a likely choice of fuel for the next decade.

Fuels Availability. The long term availability of fuels for automobiles depends upon the adequacy of the entire energy resource base, competition among alternative energy users for energy supplies and the adequacy of natural and synthetic liquid hydrocarbons. The two following charts taken from The Synfuels Interagency Task Force, indicate that only domestic and foreign petroleum can be included in the resource base until well into the 1980's.

After 1990, it is possible that synthetic liquid fuels derived from coal and shale oil could supplement diminishing supplies of petroleum, assuming the necessary investment and technical commitments were made in the very near future. The following data on future resources and costs were developed from several technical studies done recently by various private and Governmental energy groups. These studies analyzed the availability of energy resources using a variety of scenarios and assumptions concerning future patterns of energy demand and supply. Thus such factors as imports, domestic oil and gas, synthetic fuels, and coal availabilities and costs were all considered for their relative effects on the supply and costs of fuel for automobile transportation.



Primary Energy Resource Availability--
Nominal Case of the SFCP Study



Projected Sources of Primary Energy Liquids--
Nominal Case of the SFCP Study

It was generally projected by these forecasts that adequate supplies of liquid hydrocarbon for gasoline or any other refinery product slate within the next ten or fifteen years will require at least a 35 percent 6/ imported oil dependence until 1990. In addition, these forecasts anticipate the need for decontrol of domestic petroleum prices in order to stimulate secondary and tertiary oil recovery efforts. Without decontrol, the estimated domestic production level of 12.5 million barrels per day would not be reached, and imported oil dependence could rise to as much as 50 percent by 1995. The studies forecast that "synthetic" sources of liquid hydrocarbons will not make a serious contribution to the energy supply until 1990-1995, when as much as two million barrels per day could be made available.

The base cost of gasoline reflecting a variety of these scenarios was developed by the Interagency Task Force for Motor Vehicles Beyond 1980. Gasoline or distillate fuels are currently available at pump prices which range from about \$0.55 to \$0.70 per gallon (with fuel taxes at 12¢ gallon). The major component of gasoline cost is the cost of the crude and thus fuel

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6/ Imported oil dependence in October, 1976 is about 42 percent.

price movement is dominated by changes in the world price of crude or the equivalent cost of synthetic oil. Even so, with crude cost composing only 50 percent of the price of the refined fuel, doubling the cost of crude increases the refined fuel price at the pump by only 50 percent.

If there are inconsistencies in mandated fuel economy, free market choice of automobile purchase and relatively low cost automotive fuel, there may be involved divergent equations that have no solution.

The Refining Industry and a Varied Product Slate. An analysis of the U.S. refining industry was made available by ERDA in a study on the impact of automotive fuel changes on the U.S. refining industry. This study attempted to evaluate the differential effects, in terms of price, investment, and energy costs of a shift in the refinery product slate from gasoline to middle distillates, diesels, and broadcut fuels. The basic conclusion drawn concerning the possibility for varying product slates was that maximum refinery crude oil conversion efficiency was maintained as long as there existed sufficient flexibility in the variety of light and heavy products in the product slate. Refineries

were most efficient when both the light and heavy ends of the crude barrel were maintained as an operating option without a requirement to process the entire barrel into either all heavy or all light components.

Investment. The following investment table presents the differential investment requirements for the subject cases relative to baseline investment requirements.

Refining Industry Average Annual Investment of New Facilities

Case	Billions of 1975 Dollars 1/ 1980	1985	1990	1995	2000	Total
Baseline	1.1	1.3	1.2	1.1	1.4	29.9
High Gasoline Demand	1.6	2.1	1.8	2.0	2.3	49.4
Low Gasoline Demand	0.75	0.89	0.73	0.98	2.0	26.8
Diesel Fuel	1.1	1.1	0.87	2.6	2.2	39.1
Broadcut Fuel	1.1	1.1	0.49	0.98	1.6	26.4

1/ Last year of five-year period over which annual investments are averaged.

Source: Fuels and Materials Panel Report, Interagency Task Force on Motor VEhicle Goals Beyond 1980, March 1976.

The baseline case reflects the anticipated conversion of U. S. refining capacity to no-lead gasoline by 1985, when less than 15 percent of the product slate will be regular gasoline. The figures show total investment over the next 25 years ranges from $25 billion for low gasoline demand to $50 billion for high gasoline demand.

CHAPTER VII

PRODUCT DEVELOPMENT AND PRODUCTION

In the late 19th and early 20th century, the imagination and resourcefulness of inventors determined product development and lead times required for production. The advance of technology, the emergence of more complex vehicles and most recently the establishment of environmental, energy and safety regulations have lengthened the lead times needed between concept and production.

Government regulations and technical factors were examined in Chapter V, but to some extent these considerations also are involved in Chapter VII as affecting product development and product manufacture. Conformity with one regulation, for example, emission controls, may make it more difficult to comply with another regulation, for example, on fuel economy. Development problems are compounded, consequently, environmental, energy and safety regulations may have a constraining effect on product development.

New technology is seldom introduced across-the-board in a single model year in the automobile industry. This is true because of lead time requirements. Capital needs also may play a part, but one of the most important reasons is the commercial risk involved in putting millions of warrantable items into customer service without adequate experience.

Lead Time Requirements.

In the 1960's and 1970's action by Congress and State legislatures and rules and regulations initiated by governmental regulatory agencies (discussed in Chapter V) established objectives which imposed restraints on the design and development of vehicle innovations, which extended the time (lead time) needed between concept and production of the modified or new product. The legislative and regulatory actions were directed toward the objectives of clean air, safety and fuel conservation. Success in meeting them is tied to the lead times needed for designing, obtaining materials, manufacturing and delivering components, preparing production facilities and assembling the vehicles.

Currently, raw materials are in ample supply at their sources and from planned stockpiles. Some future supplies, however, are contingent on economic and political conditions overseas.

Engines probably require the longest lead time of all automotive components. Development lead times vary with different types of power plants. Lead times required to mass produce significantly different types of engines control the lead time for a significantly different type of automobile. Assuming no drastic engine changes, it can be estimated that a lead time of approximately five years is required to introduce a new model or to make a complete model change, including preliminary styling, designing, model building, testing, production tooling, materials and component procuring, and finally assembling.

The engine currently in most extensive use in automobiles, the Otto cycle gasoline engine, is undergoing modification and improvement to reduce emissions and fuel consumption. Substantial progress is hopefully anticipated through accurate metering of fuel by injection or improved carburetors, resulting in leaner, more efficient air-fuel mixtures. Maximum potential improvement of the Otto cycle gasoline engine may be achieved during the next decade with the development of improved fuel metering and ignition systems, new combustion chanber configurations (e.g. pre-combustion chambers) and stratified charge engine designs, such as the Ford PROCO.

The diesel engine is being adapted to automobiles; currently it is used in trucks, locomotives, ships, off-highway, stationary and industrial applications. Lead time for the establishment of new engine lines to result in extensive use of diesel engines in U.S. cars is similar to the anticipated lead times for improved Otto cycle gasoline engines. Introduction in U.S. produced passenger cars appears likely in the 1978 model year, with maximum potential expected by the mid 1980's. The Oldsmobile Division of General Motors announced tentative plans to market a diesel powered automobile in 1978 if a compatible NO_x emission standard is adopted.

Theoretically, the most promising of the several candidates for the ultimate automobile power plant appears to be the Stirling cycle engine. It is possible but not likely that the Stirling cycle engine may enter the market prior to 1990. Critical problems remain to be resolved to enable development of a viable production design.

Ford Motor Company is expending considerable effort on the development of this engine. Its 1975 Annual Report to Shareholders notes that "it would be 1985 or later before the Stirling engine could be readied for mass production."

Brayton cycle engines (gas turbine) have been subject to research and development for possible mass use in automobiles for 25 years. There are still many technological obstacles, but some specialists believe mass production may be possible by the early 1990's.

General Motors Corporation started experiments with a gas turbine car in 1954 and Chrysler Corporation has done extensive work on gas turbine cars since 1956. Ford Motor Company has also been active in this field since the early 1950's. The Chevrolet Division and the Truck and Coach Division of General Motors Corporation started experiments with turbine-powered trucks in 1957. The Federal Government entered the gas-turbine powered car development program when it awarded a contract for such work to Chrysler Corporation in 1972.

In 1970 the General Motors Corporation signed a five-year, fifty million dollar license agreement with Curtis-Wright Corporation for rights to develop a Wankel rotary engine. In mid-1976 General Motors announced that it had stopped funding further development of the Wankel engine because fundamental fuel economy problems remained unresolved.

The U.S. Energy Research and Development Administration is involved in a program to produce 7,500 electrically driven demonstration vehicles by 1981.

The Jet Propulsion Laboratory of the California Institute of Technology feels lead times for gasoline, diesel and Brayton cycle engines could be reduced by sufficient funding of R & D programs. (While adequate funding is necessary, the acceleration of results is not necessarily true). Given enough money, the Laboratory feels all of these engines could be put into production by 1985.[1/] It questions the outlook for electric automobiles until substantial progress has been made in technology, particularly development of storage batteries capable of longer runs between charges.

In recent years Federal laws and regulations have established lead times for certain achievements. The Energy Policy and Conservation Act (December 24, 1975) sets forth automobile fuel economy goals to be achieved by 1985. Automobile companies predict this could require that the great bulk of production be made up of cars no heavier than sub-compact, e. g., General Motors' Vega, Ford's Pinto, American Motors' Gremlin.

1/ "Should We Have A New Engine" by Jet Propulsion Laboratory, California Institute of Technology, August 1975.

Stringent Federal standards governing environmental pollutants given off by automobile engines are scheduled for application in 1978. With the industry apparently unable to meet these standards by the 1978 model year, Congress is considering a new timetable for implementation.

Each of the automobile manufacturing corporations support extensive research and development departments or divisions. A high percentage of their efforts is directed toward the development of cars which will meet the requirements of Government within the mandated lead times.

Overall Engineering and Cost Trade-Offs

Concepts reflecting overall engineering and cost trade-offs between fuel economy, safety and emissions are incorporated in models of advanced vehicles. However, progress of such advanced designs cannot be accurately forecast so these concepts will be reflected in part under headings of Fuel Economy, Safety and Emissions.

Automobile manufacturers report expenditures of more than two billion dollars for research and development during 1975: Chrysler spent \$199 million, Ford, \$748 million, and General Motors, \$1.1 billion, and American Motors Corporation, \$37 million. Corporate funds were augmented by Government participation in some programs.

Fuel Economy. Chapter V of this study points out that U.S. Federal legislation has established fuel economy goals for cars of the future ranging from 18 miles per gallon average fleet consumption in 1978 to 27.5 miles per gallon for 1985 and later model cars.

In its 1975 Annual Report, General Motors states that "substantial amounts were spent by GM during 1975 for research, engineering developments, testing, tools, and facilities to improve the fuel economy of GM vehicles. This includes weight reduction in our current vehicles through the use of new, improved, and light-weight components such as smaller engines, lighter weight transmissions, and axle revisions. It also includes bringing to market new fuel-efficient vehicles such as the Chevrolet Chevette and the all-new family size cars planned for 1977."

This same report comments that the corporation is well on its way to meeting its voluntary goal of 56 percent improvement in gas mileage by 1980 compared with 1974 models. However, the Federal Energy Policy and Conservation Act of 1975 mandates 98 percent improvement by 1985 (compared to 1974).

Weight reduction is being used by all companies as an important effort toward improved fuel economy. General Motors, for example, has reduced the weight of its full size cars by 600 to 1,000 pounds in 1977.

Ford Motor Corporation's efforts to achieve better fuel economy include continuing improvement of existing conventional gasoline engines and drivelines and intensive development of alternative engines. In 1975 Ford continued research and tests in fuel injection V-8 engines, and believes it may have a successful engine ready for production by 1980. At the same time, cooperating with a Dutch firm, Ford is developing prototype Stirling cycle engines for vehicles.[2/] Ford Research and Engineering Center is also studying possible use of gas turbines, prechamber engines, as well as batteries as potential power sources for cars.

Chrysler reports that it "had to devote an increasing share of its R&D budgets to meeting Government mandated safety, emission and fuel economy regulations." Chrysler developed a "lean burn" system in 1975 which uses electronic controls to enable an engine to operate on a lean fuel-air ratio and enable the engine to utilize any kind of gasoline. Chrysler plans a complete redesign of all products by 1980, and the plans include the introduction of a small, subcompact front-wheel-drive car.[3/]

2/ Annual Report of Ford Motor Company for 1975.

3/ Annual Report of Chrysler Corporation for 1975.

Safety. Motor vehicle companies have been, and are, particularly constrained in product development by Government safety regulations. Safety, a voluntary concern of automobile manufacturers' research for many years, is now largely directed by regulations. Congress enacted the National Traffic and Motor Vehicle Safety Act and the Highway Safety Act in 1966 and that same year the United Sates Department of Transportation (DOT) was established. Within DOT the National Highway Traffic Safety Administration (NHTSA) has responsibility for issuing regulations (under the Acts) governing safety performance and damagebility of automobiles so as to assure that the vehicles through faults of configuration do not create hazards to the health and well being of the vehicle occupants nor to persons and things in the vehicles' environs. NHTSA identifies safety rules as Federal Motor Vehicle Safety Standards (FMVSS).

The crashworthiness table on the next page lists the standards intended to reduce or eliminate the danger of injury to car occupants when the vehicle is involved in frontal collision, is struck from the side, rolls over, or burns. Hearings are held on the establishment of standards when appropriate to resolve questions of controversy.4/

4/ For example, the Department of Transportation conducted a hearing in August 1976, on the need for a rule governing automobile passive restraint systems, in connection with which the Secretary of Transportation stated: "The prospect of mandating passive restraints in automobiles has become increasingly controversial. Questions of effectiveness cost, and suspected hazards, as well as the philosophical problems of restricting individuals' freedom of choice with regard to how much they pay for safety protection, have been raised by opponents of the air bag. It is in the context of this controversy that I must make a decision as to the future of passive restraints." (Ward's Reports, June 14, 1976)

Level I Frontal Crashworthiness Requirements Effective in 1975 Cars

FMVSS	Type of Requirement
201	Interior compartment impact protection at low speeds.
202	Head restraints.
203	Impact protection for driver through energy absorbing steering column.
204	Limit intrusion of the steering column into the passenger compartment.
205	Energy absorbing glass in windshield.
207	Seat strength.
208	Occupant protection requirements.
209) 210)	Seat Belt requirements.
212	Limit ejection through windshield by specifying glass retention requirements.
219	Limit intrusion of vehicle parts through windshield. (effective 1976-80)

Side Requirements Effective 1975 Cars

205	Safety glass requirements.
206	Limit ejection through side doors.
208	Occupant protection requirements.
209) 210)	Belt requirements.
214	Side door intrusion limit.

Rollover Protection

201	Occupant interior protection.
206	Limit ejection through side doors.
208	Occupant protection requirements.
209) 210)	Seat belt requirements
212	Windshield retention.
216	Limit roof crush.

FMVSS	Fire Protection
301	Fuel leakage.
302	Flammability of interior materials.

Source: Safety Panel Report of the Interagency Task Force on Motor Vehicle Goals Beyond 1980. (March 1976)

The National Highway Traffic Safety Administration also establishes standards intended to assist in the avoidance of collisions. These "Crash Avoidance Countermeasures," are listed on the next page. Basic plans for future collision countermeasures fall into three categories; perception of hazard, reaction time for the driver, and vehicle response.

To assist in the "perception of hazards," studies of vehicle design are being conducted to identify and issue standards to eliminate, or at least reduce, blind areas, to improve lighting and to provide sensing devices to warn drivers of obstacles.

"Blind areas" are those areas of an automobile composed of solid, nontransparent materials, which limit the peripheral vision of the driver, thus limiting his prospects for avoiding a potential collision. Blind areas usually are supports for the car roof and when considering alternative designs care must be taken not to weaken the car structure.

Proposed lighting improvement to assist night driving includes consideration of increasing headlight candle power, but this must be done without creating additional glare which might endanger on-coming vehicles.

Crash Avoidance Safety Standards

FMVSS	Type of Requirement
101	Control location.
102	Transmission shift lever sequence, starter interlock and transmission braking effect.
103	Windshield defrosting and defogging systems.
104	Windshield wiping and washing systems.
105	Hydraulic service brake, emergency brake and parking brake systems.
106	Brake hoses.
107	Reflecting surfaces.
108	Lamps, reflective devices.
109	New pneumatic tires.
110	Tire selection and rims.
111	Rearview mirrors.
112	Headlamp concealment devices.
113	Hood Latch systems.
114	Theft protection.
115	Vehicle identification.
116	Vehicle brake fluids.
118	Power-operated window systems.
119	New pneumatic tires for vehicles other than passenger cars.
121	Air brake systems.
126	Truck-camper loading.
124	Accelerator control systems.
215	Exterior protection.

Source: Safety Panel Report of the Interagency Task Force on Motor Vehicle Goals Beyond 1980 (March 1976)

Sensing devices to warn drivers of obstacles could be some version of a radar system. The serious concern here is the problem of advising the sensing device whether or not the obstacle constitutes a hazard.

Government attention is being directed to two areas of possible improvement to reaction time in cases of impending collision: efforts are being made to develop a device which would warn the driver of potential disaster and simultaneously apply vehicle brakes; the second is the effort to establish means of preventing the starting of a vehicle by persons whose responses are impaired, particularly if impaired by alcohol abuse.

Vehicle response investigation is centered in studies of anti-lock brakes, and more durable brake systems.

Of importance equal to safety features of the vehicles are the safety features of the highways and their environment. Congress recognized this in the passage of The Highway Safety Act of 1973 and establishment of the Federal Highway Administration (FHWA).

The overall plan of the Administration is to assist in the identification of roadside obstacles and to either remove them, relocate them to a less vulnerable place, redesign them to make them less lethal, or add some type of protective device.

Emissions Controls. Exhaust emission control first became a requirement effective with the 1966 model year in California, they became a Federal requirement starting with the 1968 model year. The Clean Air Amendments of 1970 sharply expanded the Federal role and established stringent new emission standards for automobiles. The Environmental Protection Agency (EPA) was established to develop and to administer the pollution control program.

The need for such stringent standards, as well as the technical feasibility to meet them, has been questioned by industry. Congress continues to consider amendments to the Clean Air Act which will affect the standards and/or their effective dates.

In addition to the gaseous polluting emissions from motor vehicles, discussed in Chapter V, consideration has been given to particulate emissions, with 80-85 percent of such emissions being lead contained in gasoline. EPA has established regulations governing the amount of lead permitted in gasoline. Pre-1975 model cars using leaded fuel produce .25 grams/mile of particulate matter, whereas cars using non-leaded fuel produce about .01 grams/mile. Uncontrolled diesel powered automobiles produce approximately 0.4 grams/mile of particulates from exhausts (not lead). A potential problem of sulfate emissions from diesel engines is being studied.

Another pollutant (emission) receiving increasing attention is noise. A study for the Automobile Manufacturers Association, Inc. 5/ asked 1,200 people what neighborhood noises annoyed them. The response was: 55 percent said motor vehicles, 15 percent aircraft, 12 percent voices, 2 percent radio and TV, 2 percent home maintenance equipment, 1 percent construction, 1 percent industrial, 6 percent other noises, 6 percent not ascertained.

While this survey indicates that motor vehicle (traffic) noise appears to be the most objectionable to the people surveyed, it should be noted that traffic noise, generally at a level below 70 db, is not usually considered to be a significant contributor to hearing damage. Furthermore, people surveyed relative to neighborhood noise generally spend several hours a day indoors where traffic noise is reduced 10 to 15 db.

The major sources of motor vehicle noise are trucks, buses and motorcycles rather than passenger cars. Even though automobile noise generally does not contribute to hearing damage, the Noise Control Act of 1972 covers personal comfort and well being as well as mental anguish and annoyance.

EPA has set new truck noise standards. These are: 83 dBA maximum by January 1, 1978; 80 dBA by January 1982. To reach 83 dBA will probably require simple design changes in cooling systems and a fan clutch for heavy trucks. To reach

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5/ Prepared by Bolt Beranek and Newman, Inc., Report 2112, June 1971, entitled "Survey of Annoyance from Motor Vehicle Noise."

80 dBA will require improved cooling system plus fan clutch for heavy trucks, advanced mufflers, improvements in air intake, and improved underhood insulation.

Costs and Trade-offs. Fortunately, safety measures involving speed limits and other highway traffic measures are at no penalty to fuel economy. In fact, lower speed limits increase fuel economy.

There are no apparent direct trade-offs between emission controls and safety; there is a direct relationship, however, when fuel economy is considered. The addition of certain emission controls to automobile engines has adversely affected fuel economy. For example, General Motors Corporation reported that fuel economy had deteriorated during the period 1968 through 1974[6/]; however, fuel economy of 1977 General Motors cars, on the basis of EPA test results, is 52 percent better than 1974 (12 MPG in 1974 compared to 18.4 in 1977). The addition of stronger, heavier safety requirements (side, roof, front and rear beams or bumpers) increases fuel consumption due to vehicle weight increases.

The NHTSA is examining the benefits and costs that would result from higher frontal protection requirements. The Federal Task Force on Motor Vehicle Goals Beyond 1980 examined benefits and costs of an improvement in crash-worthiness to withstand crashes at 40 miles per hour. This examination included improvements such as 20 mile per hour side protection,

6/ 1975 General Motors Report on Programs of Public Interest, April, 1976.

post-crash egress, and anti-lock brakes. It was estimated that those improvements would result in an estimated cost of 2.5 billion gallons of fuel per year and raise prices of automobiles $360 for the required safety features. 7/

Total costs to the vehicle companies of meeting government regulations are not known with any precision, but such costs are reported to be considerable. General Motors Corporation and the Ford Motor Company have issued statements on the subject which though not completely comparable, illustrate the magnitude of costs involved.

The General Motors Corporation reported spending more than $850 million in 1974 in meeting and preparing to meet the automotive standards directed to improving safety, vehicle emission and noise controls. Ford Motor Company reported expenditures of $507 million prior to mid-1975 in its efforts to meet car emission standards. Ford's investment plans include spending over $2 billion during the period 1976-1980 to achieve major improvements in car fuel economy. The costs reported are only the research and development, capital and tools, and reliability and inspection costs where applicable. That does not include the direct cost of the hardware added to cars to meet the standards.

Laws and regulations on the subject of clean air, safety and energy conservation are applied to stationary as well as mobile sources. Accordingly, producers of autos, trucks and

7/ Draft Report of the Safety Panel of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976.

buses direct their attention and efforts to their production facilities as well as to their vehicles.

One aspect of cost or trade-off relates to overall goals. A recent Brookings study points out that while striving for the goals of cleaner air, safer vehicles and energy conservation concurrent effects and related results should be given appropriate attention.8/

"The nation has decided in favor of a cleaner environment. But it is equally committed to economic growth and a rising standard of living. The problem is that these goals, to some extent, conflict with each other.

"If carried out as intended, current pollution control laws will require over the next decade expenditures of up to half a trillion dollars by consumers, business firms, and governments, and substantial changes in industrial practices and the style of consumer living.

"Depending upon the industry or pollutant, going from say, 97 percent to 99 percent removal (of pollutants) may cost as much as the entire effort going from zero to 97 percent.

"If costs of pollution control increase to $50 billion or $60 billion per year by the early 1980's, they will absorb about 10 percent of the growth in per capita national income

8/ "Pollution, Prices, and Public Policy" - Allen V. Kneese and Charles L. Schultze. The Brookings Institution, Washington, D.C.

which would otherwise be available to raise living standards and improve conditions in other ways."

It is impractical to attempt to evaluate the trade-offs to be anticipated for advanced vehicles and advanced fuels. Such a reliable evaluation would require positive knowledge of future advancements in engineering, science, economics, Government requirements and customer demands. For example, a study by the Department of Transportation9/ commented on future developments in truck technology as follows: "It has become obvious that spokesmen for the commercial vehicle industries have no firm view or are unwilling to express such views of the future commercial vehicle and future commercial fleet operations because of their total uncertainty regarding the future regulatory environment."

Effects of Implementing New Designs

The new designs are not fully predictable at this time, consequently neither are the impacts on industry, labor, and the consumer fully discernable. Obviously, the major impact on the consumer will derive from auto prices and operating costs.

Current research and development of new materials, new alloys of previously used materials, and methods for processing them, make possible a cautious prediction regarding the materials to be used in vehicles in the future.

9/ Draft, "Commercial Vehicle Post - 1980 Goals Study," May 1976.

Weight is a primary consideration in efforts to conserve fuel. Thus, there is considerable investigation of new alloys of iron and steel to effect weight conservation. Similarly, experiments are being conducted with new plastics and new alloys of aluminum, and with new processes for forming these materials. The research includes considerations of strength of the materials (for safety), availability, cost, and effect on environment including disposition by scrap and/or recycling when the product has concluded its useful life.

Kidder, Peabody, Incorporated in a recent study10/ gave the following examples to verify the relationship of weight and fuel economy as affected by Government regulations. Between 1965 and 1974 the weight of an average compact car produced by American Motors Corporation increased 310 pounds, that is 12 percent. Only 26 pounds were the result of product features whereas the remainder was necessitated by Government regulations. At the same time greater weight and emission control apparatus reduced fuel economy 25 percent. Between 1971 and 1975 Ford Motor Company's Pinto gained 243 pounds caused by heavier bumpers, emission hardware and safety features which in turn led to an additional 120 pounds of weight. During this period the Pinto lost 10 percent of fuel economy.

10/ "Analysis of Future Automotive Materials," June 1975.

The new alloys and materials will require new manufacturing processes, retraining of production personnel, re-supply of after-market inventories, retooling and re-instrumenting service facilities, and re-training service mechanics.

Vehicle inspection of automobiles in service will probably involve controversial developments. For example Congressional consideration is being given to changing the requirements of the Clean Air Act that vehicles must be warranted by the manufacturer to maintain required emission levels for five years or 50,000 miles, reducing the requirement to 18,000 miles.

The emissions warranty provision will not go into effect until such time as a field test is developed which reasonably correlates with the certification test. Once the warranty provision has been put into effect, it is assumed that automobile owners will pay the cost of such warranty by an increase in the original purchase price, and will have to submit their vehicles to periodic inspection.

CHAPTER VIII

CONSUMER DEMAND FOR AUTOMOBILES

Car prices and designs are two of the several major factors influencing consumer demand for automobiles. A substantial reduction in car sales and a consequent lower level of economic activity and employment could follow should government actions cause large increases in car prices or force production of car types not desired by the average consumer.

Total retail automobile sales in the United States during the period 1970-75 averaged 8.9 million units annually, ranging from an all-time high of 11.4 million units in 1973 to a low of 8.4 million autos in 1970. The annual percentage change in sales varied from a plus 22 percent in 1971 to a minus 22 percent in 1974. 1/ Retail sales of automobiles in 1975 were 8.6 million units and increased to 10.1 million in 1976. The number of privately-owned automobiles registered grew steadily from 88.7 million in 1970 to 106.3 million in 1975. 2/

The share of imported new car sales has increased from 0.3 percent in 1950 to 18 percent in 1975, and declined to 14-15 percent of the new car market in 1976. New car sales averaged 5.7 million per year in the decade of the 1950's and 8.0 million per year in the 1960's compared to the 9.8 million in the period between 1970-1975.

1/ Table 8-1, Appendix
2/ Table 8-2, Appendix

During the period 1970-1975, the demand for smaller automobiles increased. The trend was encouraged by several factors, including: 1) rising cost of vehicle operation with larger cars being more costly to operate; 2) increasing urban and suburban congestion which encourages the use of smaller vehicles that are more convenient to park and drive; 3) increased multi-car households where the demand for at least one car can be met by a smaller vehicle with less occupant and cargo capacity; and 4) concern over gasoline availability.3/

In 1970, subcompacts, compacts, and imports together held 30 percent of the market, but by 1975 their share was 45 percent, an increase of 50 percent. The "regular" class share decreased by over 50 percent in the same period from 34 percent to 18 percent of the market. However, during 1976, sales of smaller cars have declined relative to sales of the larger and intermediate sizes. The 1976 mix by car size is expected to continue through 1977. The percentage share of the U.S. market of each of the market classes is shown for 1970 through 1975 in Table 8-3, Appendix.

The characteristics of the nearly 10 million automobiles sold each year vary widely. No single market classification serves all analytical purposes. The foregoing comments are

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3/ A substantial portion of this review section is from the draft (September 2, 1976) Report of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, and the draft Panel Reports.

based upon the Motor Vehicle Manufacturers Association classification. A listing of alternate market classifications is shown in Table 8-4, Appendix.

Demand Factors.

In the longer run the most significant demand factors are growth of the driving age population and growth in the level of income.

In the short term, factors such as fuel shortages and changes in employment and income levels affect new car sales.

Per capita disposable income in current and in constant dollars has risen without interruption since 1950. The United States population in the 15-75 year old age group has grown between 1.3 and 1.4 percent per year since 1950. Population in this age group in 1950 totaled 107 million. Based on this age group per capita automobile ownership was .309, and per capita new car sales was .059 during 1950. By 1973 the same population age group numbered 146 million, per capita ownership had risen to .575 and per capita new car sales rose to .079.

As real income rises car ownership by household grows, and more households acquire second and third cars. At high income levels, a saturation in the demand for additional automobiles is evident, with further income increases producing very little change in auto ownership.4/

4/ Federal Highway Administration, Nationwide Personal Transportation Study, 1969-70.

Other factors in addition to increased affluence have contributed to auto ownership. Highway quality has steadily improved, and so has the technology embodied in the automobile, e.g., automatic transmissions and power steering. These changes have combined to make driving a feasible option to practically every American of driving age.

Contrary to some expectations, the building of additional rapid transit systems may not have a great effect on automobile demand. The availability of rapid transit systems changes the auto ownership profile only slightly from the rest of the nation, except in New York City, where vehicle ownership per household is about 40 percent lower than the national average. In all other rapid transit cities, ownership rates are about 12 percent lower than the national average on a per household basis and 3 percent lower on a per capita basis.

Cars last an average of about 10 years before they are scrapped and replacement of these cars is an important element in new car demand. During the years 1970-75 an average of 6.7 million cars were scrapped each year. (For historic scrappage rates of the automobile fleet by vehicle age, see Chapter 5.) Year-to-year scrappage rates are very low in the first few years of a car's existence (representing mostly accidents). They rise rapidly through the mid-years, then level off at about 30 percent per year. After five years more than 90 percent of cars are still on the road but after 14 years, less than 10 percent remain.

Future Trends and Consumer Demand.

Factors external to the automotive industry itself, such as safety, energy and environmental considerations may be translated into Government regulations which affect the size, performance and price of autos and, hence consumer demand.

Automobiles provide an unexcelled means of personal mobility and it is unlikely that the desire of individuals for the freedom and convenience of travel by car will diminish. During the past 40 years, the mobility provided by automobiles has been implicit in the location of newly constructed homes and commercial enterprises. A growing energy shortage could force changes in the pattern of new construction but the existing cities, towns, and suburbs cannot be replaced except in a longer time span.

In looking toward 1985, consumers' expenditures for cars are expected to remain a relatively stable proportion of total consumer expenditures and the number of cars sold is expected to vary as the price of cars varies in relation to the general price level. Since 1955 personal consumption expenditures for autos and parts have averaged 6.7 percent of total personal consumption expenditures ranging from a low of 5.3 percent in 1958 to a high of 7.3 percent in 1972. For a number of years the prices of automobiles rose less than the general price level. From 1950 to 1975 the consumer price index for all items rose

124 percent while the index for new passenger cars rose 54 percent. For the period 1970-75 the increase in the consumer price index for all items was 37 percent and the increase of the new car index was 19 percent.5/ With the end of the era of declining energy prices we appear to be entering a period of changing patterns of price relationships and market preferences. Higher energy costs are expected to be reflected in higher prices of most - if not all - manufactured goods, and the cost of automobile operation may increase more rapidly than the general price level. This condition would be expected to depress overall new car sales. Although consumer preference for lighter, more fuel efficient cars would be stimulated, the shift in demand for smaller cars could be substantially less than required for achieving the Government's motor vehicle fuel economy goals beyond 1980.

With respect to the impact of Government regulations, car prices have been -- and will continue to be -- significantly affected by the cost of equipment and research necessary to meet the standards adopted for safety, energy and environmental reasons. This factor could be an additional adverse influence on future new car sales. A matter of general concern is the possibility of low consumer acceptance of models offered to

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5/ Table 8-5, Appendix

comply with the Government's fleet fuel consumption standard of 27.5 miles per gallon. An unfavorable consumer response could have a severe impact on both the automotive industry and overall U.S. economy. The Federal Task Force on Motor Vehicle Goals Beyond 1980 has identified the issue of consumer acceptance as "the major dilemma facing the Federal Government and the industry" in achieving the Government's motor vehicle fuel economy goals.

CHAPTER IX

CAPITAL REQUIREMENTS AND SOURCES OF FINANCE

In year to year business operations, firms in the motor vehicle industry need capital to expand plants, to buy equipment and tooling and to replace plant and equipment that wear out or become obsolete. They also need working capital. In recent years, the industry also has had to invest extra capital to meet government standards for emission controls, both for vehicles and manufacturing plants, and for passenger safety in vehicles. These extra requirements can be expected to continue in the future, and additional capital will also be required to develop and build vehicles that meet the new fuel-economy standards.

Requirements for Capital

Period 1970-1975. The industry's past capital requirements may be measured by its expenditures for new plant, equipment and special tooling. The table below shows these expenditures since 1970. Expenditure levels during this period reflect an accelerating investment in product changes required for compliance with government regulations concerning safety, damageability and emissions control. The decline in 1975 is cyclical, reflecting cash flow problems that resulted from the sharp downturn in sales.

Expenditures for New Plant, Equipment and Special Tooling, Motor Vehicle Industry, 1970-1975
(Billions of Dollars)

Year	New Plant & Equipment	Special Tooling	Total
1975	$1.9	$1.7	$3.6
1974	2.6	2.0	4.6
1973	2.3	1.9	4.2
1972	1.8	1.5	3.3
1971	1.8	1.2	3.0
1970	1.9	1.9	3.8
Total	$12.3	$10.2	$22.5

Source: Interagency Task Force on Motor Vehicle Goals Beyond 1980, Draft Report, September 2, 1976.

Period 1976-1980. Automotive industry officials estimate domestic capital expenditures will average $4.5 - $5.0 billion annually during this period. These projections basically cover only the downsizing of vehicles currently planned through 1980 and refinements of existing powertrain systems. Since technology has not advanced to the point that alternate engines or advanced concept transmissions can be planned for specific model year introductions, no provision has been included in these projections for innovations of this type. This point is critical to this analysis in that major capital requirements would be involved; for example, complete conversion (industry-wide) to a new type engine would require an investment for facilities and tooling in the area of $10 billion. Although not of comparable magnitude, replacing current automatic transmissions with a new concept transmission would involve a multi-billion dollar investment.

However, large-scale conversion to new concept engines and/or transmissions is not likely during the next decade. A more probable scenario is a massive shift in mix to smaller displacement internal combustion engines. Additional capital expenditures of approximately $5 billion will be needed to modify or build the 25 engine production lines required to change current domestic engine production capacity to a substantially higher proportion of smaller engines. The proportion would change from producing mainly (about 75 percent) relatively high horsepower (greater than 125 h.p.) output 8-cylinder engines to producing mostly lower horsepower (less than 125 h.p.) 6-and 4-cylinder engines.

<u>Period Beyond 1980</u>. The industry's capability to raise the capital required for achieving the government's goals for motor vehicles beyond 1980 is considered uncertain at this time. In the immediate past, annual expenditures of $3-4 billion have been adequate for annual model changeovers, an all-new body shell every 5 to 10 years, and changes to comply with the government's earlier, less severe automotive safety and environmental requlations. However, this level of capital expenditures does not provide for engine and transmission changes that will apparently be required to meet long-range fuel efficiency and exhaust emission objectives. Although projecting capital expenditure rates beyond 1980 is conjectural at the present time, it appears that a level approaching $6 billion annually could ultimately be required.

The projections previously mentioned covering both the 1976-1980 period and beyond 1980 are in terms of 1976 dollars and do not include any factor for future inflation. Thus, a $6 billion capital expenditure in the mid-1980's, assuming a relatively moderate inflation rate of 5 percent annually, would be between $9 and $10 billion.

Sources of Capital. Like most other industries the motor vehicle industry may finance its capital expenditures with funds from four sources: depreciation allowances, profits, debts and equity.

Historically, the automotive industry has relied primarily on internal financing to provide for capital requirements. In this decade, however, the industry has been forced to move to long-term debt for a portion of its financing. The data in Table 9-1 in the Appendix, showing selected summary balance sheet and operating items, indicate a sharp increase in long-term debt from $2.6 billion in 1969 to $6.0 billion in 1975. As shown in the following table for calendar years 1971-1975, the after-tax return on sales of the automotive industry deteriorated substantially during the period, whereas the rate for all manufacturing corporations remained essentially constant.

Profitability of Automotive Companies Compared with All Manufacturing

Year	After Tax Earnings as Percent of Sales: Big Four	All Manufacturing
1971	5.0	4.1
1972	5.3	4.3
1973	5.0	4.7
1974	1.9	5.5
1975	1.3	4.3

Source: Report of the Automobile Industry Task Force of the House Banking Committee, dated July 1976.

The automotive industry's profit performance (on the basis of return on sales) during the peak sales years of 1972 and 1973 was low compared to the previous sales peak in 1965 when a return on sales of 8.0 percent was achieved. The sharp decline in automotive industry profitability after 1973 was influenced strongly by the 1974-75 recession. Although 1976 was a year of dramatic recovery in both sales and total profits, the Big Four's after-tax return on sales increased only to 4.5 percent.[1/] The strong sales and total net earnings performances of 1976 are expected to continue through 1977. The industry has a high ratio of fixed to variable costs which results in very wide earnings fluctuations with changes in volume. Anticipating customer resistance, the industry has been reluctant to establish

1/ Annual stockholders reports of the Big Four.

prices which would accomplish full recovery of its cost increases at normal volume levels, and may be vulnerable to a sales decline.

Financial officials of the larger firms indicate that in the past the motor vehicle industry has financed most of its capital expenditures from internal sources - depreciation allowances and retained earnings. But external financing has been used by some firms through convertible and other bonds, and long-term loans. Equity financing has seldom been used in recent years.

The data in Table 9-1 of the Appendix, showing selected balance sheet and operating items, confirm this financing pattern over the period 1969-1975. The depreciation allowances of $15.6 billion and retained earnings of $4.8 billion from 1970 through 1975 were almost sufficient to finance the expenditures for new plant, equipment and special tooling of $22.5 billion shown in the expenditures table on page 9-2. 2/ The balance of capital expenditures and other operating needs were met by increasing funds from outside sources (long term debt and capital stock) by about $4.3 billion. Financing patterns in the industry in the future are expected to differ in that greater reliance will be placed on outside sources.

2/ Differences in classification systems keep the two sets of data from being strictly comparable.

There are risks in an accelerated product changeover to meet the automotive fuel efficiency, emissions and safety objectives. The Federal Task Force on Motor Vehicle Goals Beyond 1980 recognized this in its statement of risks and issues and in the following paragraph from Chapter 15 (titled "National Economic Impact") of its September 2nd draft report.

"Potential for trouble would develop, however, if a scenario failed. Failure, in turn, could take several forms: (1) major investments which produce unsatisfactory results; (2) severe buyer resistance which reduces auto sales by 25 percent or more; or (3) a major auto manufacturer goes bankrupt. Such a failure would be most likely to occur during a general economic downturn. In such a context, the multiplier effects of a major U.S. corporation failure could have wide-ranging impacts -- affecting the supplier chain, the dealer chain and the unemployment situation significantly, as well as precipitating serious stock-market repercussions."

CHAPTER X

INTERNATIONAL ASPECTS

The growth patterns of world automobile production and trade for more than fifty years have been marked by two basic types of cars, the American and the European. This is a generalization as there are exceptions. The principal difference between the two types has been size with the European cars generally smaller although there are other differences and there are various reasons for the growth of these types. It is important to note that for many years neither type penetrated the other's home market very deeply. Further, when American automobile companies produced cars in Europe, the type was basically European.

U.S. automobile companies first entered European markets by exporting completed products to Europe or by exporting parts and components for assembly in Europe. The U.S. companies then established manufacturing plants as a means of maintaining a sales market. Now Volvo and Volkswagen are entering the U.S. market for the same reasons, with some usage of U.S. components. Japanese car producers reportedly also are considering production in the United States.

The import of cars into the United States, both from Europe and Japan, generates imports of parts and components to service these cars. The import statistics, discussed later

in this chapter, do not make a distinction between parts for replacement and parts for assembly (original equipment). To date the trade has been almost entirely for replacement, although now that the smaller car is being made in the United States, there will be some original equipment importation of components from overseas for some models.

The best estimates of industry specialists indicate that automobile import penetration will be approximately 15 percent through 1985. The importing of replacement parts will hold in parallel. The importing of original equipment parts for assembly will be variable, as new models are tested with overseas-made components and then sourced in the United States when volume U.S. production of the vehicles may be justified and scheduled. Although, as described in this chapter, there are trends in automotive world trade emphasizing the growth of specialization in parts production, this trade is primarily between countries in particular trade areas. Detailed analysis in this chapter fails to provide evidence of extensive imports of original equipment parts into the United States, nor is there any evidence to indicate important growth in this classification.

The search for more efficient methods of production has resulted in the growth of two concepts of production and trade in recent years - the "International" car and "Complementation".

The former involves the production of the same or similar models in two or more countries by the same motor vehicle manufacturing company, and the latter refers to the production of parts and components in one country for assembly into cars in one or more other countries. These concepts are sometimes viewed as new development. However, complementation in parts and components actually seems to follow the reduction of trade barriers in general and the establishment of free trade areas with resulting rationalization of production.

The section on manufacturing and trade includes Canada but the discussion of imports and exports in this chapter excludes trade with Canada. Automotive trade with Canada is influenced by the United States-Canada Automotive Products Trade Agreement which has integrated the North American automotive industry. The special circumstances of the Agreement do not apply to U.S. automotive trade overseas and hence the discussion of that trade appropriately does not cover Canada. Details of automotive trade with Canada are given in the Annual Report by the President to the Congress on the Operation of the Automotive Products Trade Act of 1965, and summarized in chapter IV.

Manufacturing Plants and Trade in Foreign Countries

Automobile manufacturing and/or assembly is carried on by U. S. companies in many countries around the world. The distinction between manufacturing and assembly (in terms of corporate activity in foreign countries) is clear in principle but the precise definition may vary with country and usage. In the United States an automobile company typically assembles cars in specific assembly plants and manufactures in other plants. Assembly plants are in strategic geographic locations both here and abroad. However, in many foreign countries the assembly is made from matched sets of parts shipped from the United States. The progressive manufacture of parts in the assembly country results in greater industrialization, and at some point a change in terminology is necessary and the operation becomes "manufacturing" rather than "assembly".

"Local content" regulations aim at reducing the parts and components produced abroad in favor of those produced locally. The objective is to build gradually a totally domestic auto industry and to improve the balance of payments position. The impact of these requirements is that a US-based auto manufacturer must choose between compliance to local regulations or relinquish any role in the host country market.

For the purpose of this chapter, however, attention is primarily given to the major automobile producing countries which generally have a relationship to the U. S. market, supplying either cars or parts to this country.

The motor vehicle manufacturing countries reviewed in this chapter are: Japan, France, Germany, United Kingdom, Italy, Canada, Brazil, Australia, Mexico and Sweden. These countries are listed in order of production volume in 1975. U. S. motor vehicle manufacturing companies own production facilities in these countries with the exception of Japan, Italy and Sweden. However, some U. S. companies have vehicles produced in Japan by special arrangement with affiliated Japanese companies.

During 1974 motor vehicle manufacturers throughout the world produced and assembled approximately 37.1 million units (not including truck trailers). The United States and Canada produced about 11.5 million of these units. U. S. vehicle manufacturing plants in other foreign countries accounted for over 4.0 million units. A large number of additional countries assemble automobiles from imported parts, with or without locally procured content.1/

1/ The two classifications of motor vehicle production are responsible for occasional double-counting in international motor vehicle statistics. U. S. production figures include completely knocked-down (CKD) parts that are exported for assembly in overseas locations; when assembled these units are counted again in the production of the overseas country. No authoritative estimate of the extent of this double-counting exists, but it is believed not to exceed 10 percent of world-wide totals.

In 1974 total Free World production of passenger cars was divided, North America 31 percent, Europe 49 percent, Japan 14 percent, and the rest of the world 6 percent.

A country's automotive industry may fall in two general categories: (1) an automotive manufacturing industry, i.e., one that produces parts and components and assembles them into a complete vehicle, and (2) a vehicle assembly industry, i.e., one that assembles vehicles using mostly imported parts. Various countries have shifted, or are in the process of shifting, from the assembly category to manufacturing, due, in part, to local content laws.

Australia. Australia produced 350,000 motor vehicles in 1975, 295,000 units, or 84 percent of which were produced by subsidiaries of U. S. manufacturers. General Motors at 134,000 units, Ford at 120,000 units, and Chrysler at 36,000 units, were the leaders in production.

Australia imported 329,000 motor vehicles in 1974, 199,000 units from Japan, 29,000 units from West Germany, 18,000 units from the United Kingdom, 13,000 units from France, 10,000 from Sweden. U. S. exports of motor vehicles to Australia totalled 2,000 units in 1974.

In 1974, Australia exported 10,115 units or 2.4 percent of its 416,000 production, 6,000 of which went to New Zealand.

Brazil. Brazil produced 930,000 motor vehicles in 1975, about 40 percent (369,000 units) of which were produced by subsidiaries of U. S. producers. Volkswagen was Brazil's principal motor vehicle producer (503,000 units) followed by General Motors (174,000 units), Ford (170,000 units), Mercedes Benz (44,000 units), and Chrysler (24,000 units).

Motor vehicle exports in 1974 reached 61,000 units against 2,457 units imported.

Canada. Canada's production of motor vehicles in 1975 was 1.4 million units making Canada the sixth largest vehicle producer in the world. The United States is by far Canada's largest automotive trading partner. The Agreement Concerning Automotive Products Between the Government of the United States and the Government of Canada signed in 1965 achieved integration of the United States and Canadian North American automotive industries resulting in substantial growth in vehicle production and an even larger growth in automotive trade between the two countries. The integration of the automotive industries in the United States and Canada (North American Automotive Industry) applies to the production and use of original equipment parts and components as well as motor vehicles. Total automotive trade between Canada and the United States grew from $700 million in 1964 to $6 billion in 1970, and to over $17 billion in 1976.

In 1974, about 95 percent of Canada's total automotive exports of $5,705 million, and 90 percent of the $7,128 million in automotive imports, were in trade with the United States.

Canada's foreign trade in automotive products - excluding United States trade which is based on the special condition of an integrated industry - reached $348 million in exports (the two largest export markets are Australia at $29 million or 8 percent and South Africa at $2.3 million at 7 percent) and $705 million in imports (49 percent or $345 million from Japan and 21 percent of $148 million from West Germany).

U. S. motor vehicle manufacturers have 30 plants in Canada, including manufacturing and vehicle assembly operations which produced 1,446,000 units in 1975. Geographically, the heaviest concentration of these plants falls in the province of Ontario. Chrysler assembles trucks and cars (286,000 vehicles in 1975), and manufactures engines and springs in 5 plants in Windsor; it manufactures parts in its Ajax and Toronto plants. General Motors of Canada, Ltd. (597,000 vehicles in 1975) produces vehicles in Ontario at London, Oshawa, and Scarborough, and in Quebec at St. Therese. Parts are produced in Ontario at St. Catherine's and at 2 plants in Windsor. Ford (481,000 units in 1975) operates two engine plants and one castings plant in St. Thomas and a glass plant in Niagara Falls, all in Ontario. American Motors builds cars in Brampton (48,000 vehicles in 1975), and produces engine blocks in Sarnia and soft trim in Stratford, all in Ontario.

Both International Harvester (15,000 vehicles in 1975 at Chatham) and Mack Truck (4,000 vehicles in 1975 at Oakville) build trucks at Ontario locations. Three heavy duty truck manufacturers have plants in British Columbia - White Motors, Peterbilt of Canada, and Canadian Kenworth Ltd.

In the past other foreign firms have assembled cars in Canada but at present the only major non-U.S. firm is Volvo which assembles cars (14,000 in 1975) mostly from imported parts in a plant at Halifax, Nova Scotia.

Canadian emission standards for motor vehicles are less stringent than those in the United States because, according to the Canadian Department of the Environment, the problem of motor vehicle pollution is less serious in Canada than in the United States.

<u>Japan</u>. Japan <u>produced</u> 6.9 million motor vehicles in 1975, all by domestic manufacturers. Toyota with 2.3 million units and Nissan with 2.1 million units were the industry leaders; Toyo Kogyo with 643,000 units (56,000 of which were Courier pick-up models produced for Ford for sale in the United States) and Mitsubishi with 520,000 units (60,000 of which were Colts made for Chrysler for sale in the United States) were third and fourth, respectively. Others were Honda, 414,000 units and Isuzu, 245,000 units (46,000 of which were the Luv pick-up made for General Motors for sale in the United States).

In 1974, Japan exported 2.6 million units out of 6.6 million production, 1.0 million of which went to the United States. Western Europe imported 387,000 Japanese motor vehicles, the principal markets being United Kingdom (96,000), the Netherlands, Belgium, and Portgual. In the Near East, Saudi Arabia imported 65,000 units, Australia (248,000) Canada (138,000), and the Republic of South Africa (127,000) were also important importers of Japanese vehicles.

Japanese imports of automobiles in 1974 reached 51,000 units led by 24,000 from West Germany, 14,000 from the United States, and 9,000 from Belgium.

The European Economic Community and the United States have protested to the Government of Japan the delays motor vehicle exporters to Japan encounter in satisfying Japanese safety and emission standards requirements, a non-tariff trade barrier. Problems encountered in testing and re-inspection cause an average three-month delay in new model introduction, restricting the market. The protests point out that Japanese cars do not encounter such delays coming into the EEC and U. S. markets.

Annual production growth by Japan's automobile manufacturing industry is expected to fall to an average of only 2.8 percent over the 1975-1985 term compared with the extremely

high yearly output expansion rate of 17.4 percent achieved in the years between 1965 and 1973.2/

France. France produced 3.3 million motor vehicles in 1975, 474,000 or 14.3 percent of which were produced by the French subsidiary of Chrysler. In order of volume France's principal motor vehicle producers in 1975 were: Renault, 1.4 million units; Citroen, 693,000 units; Peugeot, 660,000 units; and Chrysler (Simca), 474,000.

Of the 12 plants in France operated by U. S. motor vehicle manufacturers, Chrysler has 8, General Motors 2, and both Ford and American Motors (Jeep) 1 each.

Chrysler has both manufacture and assembly at Poissy, and manufacturing at Sully-sur-Loire, Bondy, Dompiere-sur-Loire, La Rochelle, Valenciennes, and Vieux-Conde.

General Motors manufactures automotive components at Gennevilliers (Seine) and automatic transmissions at Strasbourg. Ford's sole installation in France is a manufacturing plant (transmissions) at Bordeaux. American Motors has a manufacturing facility for its Jeep Division at Saint Denis.

In 1974, France exported 1.7 million units, or 48 percent of

2/ Forecast developed by the automobile subcommittee of the Industrial Structure Council's Machinery Industry Division for submission to the Ministry of International Trade and Industry (MITI). From Journal of Commerce, March 8, 1976.

its 3.5 million motor vehicle production. Of these 1.2 million units went to other Western European countries, principally Spain (291,000), Italy (220,000), Belgium (149,000), the Netherlands (137,000), and Switzerland (51,000). Only 23,000 units were exported to the United States in 1974.

France imported 357,000 motor vehicles in 1974, principally from West Germany (132,000), Belgium (111,000), Italy (86,000), and Japan (15,000).

West Germany. West Germany produced 3.2 million motor vehicles in 1975, 1.1 million units of which, or 34 percent, were produced by the German subsidiaries of U. S. companies. General Motors and Ford each have four manufacturing or assembly plants in Germany. In order of volume, Germany's principal manufacturers in 1975 were: Volkswagen 1.1 million units, Opel (GM) 658,000 units, Daimler-Benz 495,000 units, Ford 413,000 units, and BMW 217,000 units.

In 1974 Germany exported 60 percent, or 1.9 million of its 3.1 million unit production, 655,000 of which went to the United States. Other Western European countries imported a total of 875,000 units, principally France with 132,000, Belgium/Luxembourg 120,000, Netherlands 106,000 and Italy 97,000. Both the Belgium and Netherlands figures reflect some double counting as both nations import unassembled parts and after assembly re-export the units to other nations.

German imports of motor vehicles in 1974 reached 661,000 units, principally from Belgium (262,000), France (242,000), Italy (117,000), and Japan (20,000).

Volkswagen's recent decision to assemble vehicles in the United States will have a substantial long range effect. It is believed that for several years the movement of parts from Germany for assembly in the U. S. factory will keep automotive export volume near its present level.

General Motors' decision to switch production of export Opels from West Germany to Japan will cause some reduction in West German car exports; in 1975 40,000 Opels were imported by the United States.

Italy. Italy produced 1.5 million motor vehicles in 1975. The producers were Fiat (1.2 million), Alfa Romeo (192,000), and Ferrari (1,337 units). The United States has no subsidiary assembly plants in Italy.

In 1974 Italy exported 678,000 units of its 1.6 million unit production, 413,000 of which went to Western European countries, West Germany (117,000), France (86,000), United Kingdom (49,000) and the Netherlands (35,000). The United States received 108,000.

Italian imports in 1974 reached 430,000 units, principally from France (220,000), West Germany (97,000), Belgium (58,000), and United Kingdom (54,000). Italy imported less than 500 units from the United States in 1974.

United Kingdom. In 1975 the United Kingdom manufactured 1.6 million motor vehicles, 895,000 (54.3 percent) of which were produced by subsidiaries of U. S. companies. British Leyland had the largest market share, 738,000 units, followed by Ford with 459,000 units, Chrysler with 246,000 units, and Vauxhall (GM) with 190,000 units.

There are 26 plants in England, Scotland and Ireland engaged in manufacture/assembly of automotive products owned and operated by Chrysler, Ford, and General Motors. The major plants of these companies are as follows:

Chrysler operates four plants in Coventry (manufacturing) plus a large die-casting operation in Birmingham. Vehicle assembly takes place at Dunstable; manufacture and assembly plants operate at Luton, Maidstone, and Linwood, Scotland.

General Motors manufactures and assembles cars and trucks in Dunstable (2 plants), Ellesmere Port, Liverpool, Luton and Southampton.

Ford has manufacturing/assembly operations at Dagenham, Halewood, and Southampton and manufacturing at Basildon, Leamington, and Woolwich.

In 1974 the United Kingdom exported 725,000 units or 37 percent of its 1.9 million production, 73,000 units of which went to the United States. Other Western European countries imported a total of 257,000 units, led by Italy (54,000), Belgium (49,000), Ireland (36,000) and Portugal (21,000 units).

In the rest of the world, the largest importer of British motor vehicles in 1974 was Iran with 76,000 units, followed by Nigeria (63,000) and New Zealand (58,000).

British motor vehicle imports in 1974 reached 281,000 units principally from Japan (96,000), West Germany (72,000), Italy (49,000), Sweden (33,000), and Belgium (20,000).

Mexico. In 1975 Mexico produced 361,000 motor vehicles and of these 183,000 units, or 50 percent were completed by subsidiaries of U. S. companies. Other (foreign) major producers were Volkswagen de Mexico (105,000 units) and Nissan Mexicana S.A. (35,000 units).

American Motors has one plant in Mexico City with manufacturing and assembly for both AMC cars and jeeps. Vehicle production reached 24,000 units in 1975.

Chrysler has a manufacturing/assembly plant at Toluca, and assembly only in Mexico City. Vehicle output in 1975 was 65,000 units.

Ford, with a manufacturing/assembly plant in Mexico City, produced 56,000 units in 1975.

General Motors has two manufacturing plants, one in Mexico City, and one in Toluca, which together produced 36,000 vehicles in 1975.

In 1974 Mexico exported 20,000 vehicles, 16,000 of which were Volkswagens. Import of motor vehicles is strictly limited; import licenses are required for each unit and are issued in limited quantities.

Local content requirements for vehicles produced by subsidiaries of foreign motor vehicle manufacturers in Mexico are already 60 percent and consideration is being given to revising them upward.

Sweden. Sweden produced 367,000 motor vehicles in 1975, all of domestic manufacture. Volvo was the largest producer (256,000); Saab-Scania produced the remainder (110,000).

In 1974 Sweden exported 196,000 units of its 368,000 unit production. Other Western European countries received 98,000 Swedish exports with the United Kingdom importing 33,000 units. The United States and Canada imported 67,000 Swedish vehicles (55,000 and 12,000, respectively).

Swedish motor vehicle imports in 1974 amounted to 182,000 units, 85,000 of which came from West germany, 29,000 from France, 22,000 from Italy, 20,000 from Japan, and 14,000 from Belgium.

Manufacturing of Parts and Components

Some American manufacturers of automotive components and parts have established production facilities overseas as corporate divisions or subsidiaries, or as joint ventures with

nationals of the host country, or through licensing agreements. The principal objectives of these establishments is to produce parts and components for both the U. S. automobile and the "national" automobile manufacturers who are established in these countries or in nearby countries.

The motor vehicle manufacturers usually produce the majority of the parts and components going into their own vehicles, but this may vary between companies and between locations and according to local regulations regarding content. Chapter IV contains a discussion of the many factors which enter into the motor vehicle manufacturer's decision whether to "make or buy". This kind of analysis applies equally to international operations. The lack of precise distinction and definition between parts and components is also discussed in that chapter.

American corporations manufacturing or assembling vehicles overseas evaluate the economic advantages and disadvantages of procuring parts and components locally from independent suppliers or by establishing foreign subsidiaries or by importing from their United States sources.

The principal countries in which some of the major American independent components and parts manufacturers are now producing include Argentina, Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, Mexico, New Zealand, Poland, Romania, South Africa, South Korea, Spain, Switzerland, United Kingdom and Venezuela.

United States independent components and parts manufacturers engaged in overseas production include, among others:

Bendix Corporation	Dana Corporation
Borg-Warner Corporation	Eaton Corporation
The Budd Company	Federal-Mogul Corporation
Clark Equipment Company	Gould Incorporated
Kelsey Hayes Incorporated	The Timken Company
Lear Siegler Incorporated	The Torrington Company
Monroe Auto Equipment Company	TRW Incorporated
North American Rockwell Corp.	Twin Disc Incorporated
A. O. Smith Corporation	

Although not all-inclusive, the foregoing list represents a large segment of better known automotive components and parts manufacturers who are engaged in production outside the United States. Items produced by these companies include brake systems, fuel pumps, transmissions, frames, wheels and wheel parts, engines, axles, drive shaft parts and assemblies, gaskets, engine parts, bearings, batteries, and body parts.

General Motors Corporation manufactures parts and components in Great Britain, Ireland, Germany, France, Iran (in a partially owned company), Japan and the Philippines. Ford manufactures parts and components in the United Kingdom, France, Belgium, Venezuela, Germany and Brazil. Chrysler Corporation manufactures parts and components in Australia, Brazil, Mexico, Spain, Argentina, France, Turkey, South Africa, and the United Kingdom.

Technology Levels

Automotive production equipment and engineering services are traded with little or no restrictions among Free World countries. Automotive production is most efficiently carried out by large plants incorporating massive amounts of machinery and sophisticated control equipment. Such plants require considerable capital investment and the major automotive manufacturers are relatively large, and international in scope. These companies can draw on the best technology available in any of their worldwide plants when new plants are being established or old plants modernized. Because of these conditions the movement of technology between nations is relatively easy and rapid. The flow of technology is also relatively rapid between unrelated companies in various countries as well, and as a result the technology used in most countries is similar. The actual level of technology in any given producing countries is therefore primarily dependent on the size of the market and the scale of production and investment that the market can support; no one country maintains a restrictive technological advantage in this industry for any extended period of time.

Labor Considerations

As detailed in Chapter IV, complete manufacture of automobiles requires a large skilled labor force. Such a range of skills is found in the more industrialized nations

and is one of the necessary factors that assists the growth of an automotive manufacturing industry. Assembly of vehicles can be done with a narrower range of skills than is required for more complete vehicle manufacturing operations. Developing countries usually begin an automotive industry by establishing assembly operations using imported components and gradually increase the proportion of domestically produced parts.

In general the lack of skills alone does not appear to have hampered the growth of an economic vehicle industry. Countries with income levels high enough to sustain sufficiently large automobile markets to allow economic production are usually already industrialized to the point of having the labor skills necessary for automobile manufacture.

The level of total compensation is one of the factors affecting a country's production costs and the competitive position of its industry in international trade. Total compensation per production worker in the United States motor vehicle industry is the highest and the total in Japan is the lowest among the industrialized automobile manufacturing countries.

The following table compares the estimated compensation per hour worked in mid-1975 for the principal automobile manufacturing countries.

Estimated Compensation Per Hour Worked[1/]

	US Dollars	Index US=100
United States	9.29	100
Germany	7.94	85
Canada	7.76	84
Sweden	7.24	78
Italy	4.99	54
France	4.92	53
UK	3.77	41
Japan	3.61	39

1/ Total compensation per hour worked is estimated by adjusting average hourly earnings to include items of direct pay not included in earnings, and employer expenditures for social security and contractural and private insurance programs.

Source: U.S. Department of Labor

The above figures indicate that other factors are more important than labor costs in decisions to invest overseas. In general, U.S. based automobile corporations have invested in countries where labor costs are relatively high.

Productivity

A comparison of motor vehicle industry productivity trends among the United States, Japan, and three European countries for the period 1965-1974 shows that Japan clearly outdistanced the others, posting an annual average productivity gain of 13.6 percent. From 1965 to 1973, Italy and Germany registered productivity growth rates of about 6 and 4 percent respectively, followed by the United States at 2.9 percent. The United Kingdom showed the lowest rate of gain with an average growth rate of 1.1 percent over the

period. Information is not readily available for estimating the productivity trends in two other leading autoproducing countries, France and Sweden.

All five countries show erratic year-to-year fluctuations in productivity. In general, sharp output increases were accompanied by substantial gains in productivity and declines or small increases in output were accompanied by low gains or decreases in productivity.

All five countries experienced reductions in demand for motor vehicles in 1974, and output fell significantly in each country. As hours were cut less drastically, each country also had a drop in productivity. U.S. output continued to fall in 1975, but preliminary data indicate that productivity increased slightly as employee-hours declined more sharply than output. Output also continued to fall in Italy and the United Kingdom. Consequently, they probably had further declines or only small gains in productivity. Output in Japan and Germany, however, appears to have moved upward during 1975.

These inter-country comparisons of trends in motor vehicle productivity should not be considered precise. The U.S. industry definition was used as the point of reference, but there are some variations in product coverage among the countries. In particular, the data for Japan for the period of 1965 to 1970 relate to all transportation equipment

except railway equipment and shipbuilding. Also there are differences among the countries in the methods and measures used to record changes in both output and hours. For a brief description of each country's series, see Table 10-1 and 10-2, Appendix, and the notes accompanying the tables.

Laws and Regulations in Foreign Countries

The automobile industry has suggested that the major vehicle producing countries effect an international standardization of laws and regulations relating to clean air, safety and fuel economy since the current differences between countries necessitate modifications of vehicles manufactured in one country and sold in another. Early in 1974 it was reported[2/] that cars being imported into Europe had to be altered at costs ranging from $17 to $300. American Motors Corporation stated that it believes that 50 hours of labor is required on each AMC car sent to Europe in built-up form to bring it into compliance with local requirements.

The European Economic Community (E.E.C.) has established air quality standards for hydrocarbons, carbon monoxide and oxides of nitrogen, following to a degree the initiative of the United States Government. However, the test methods used in Europe are different from those in the United States,

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2/ "Automotive Industries", February 1, 1974

making comparison difficult according to a recent study.3/

The study reports further that vehicle smoke emissions are the subject of regulation in Brazil, Canada, Finland, France, Mexico, Norway, Philippines, Spain, Sweden, Switzerland, and Yugoslavia. The regulations are not necessarily the same for each of these countries. Some confine their regulations to heavy duty trucks, some to diesel engine-powered vehicles and some to other classifications of vehicles.

The Japanese Environment Agency, for example, has established automobile emissions standards for 1978: nitrogen oxide, .25 grams per 1 kilometer run, carbon monoxide, 2.10 grams and hydrocarbon emission, .25 grams.4/ These regulations have the effect of restricting Japanese vehicle imports since foreign manufactures are having difficulty complying. The U.S. automobile industry is hopeful that the negotiations currently underway will lead to a more satisfactory arrangement with Japanese authorities.

3/ "Collection, Tabulation, Codification and Analysis of the World's Air Quality Management Standards", 1974, Professor Authur C. Stern, University of North Carolina.

4/ Letter from Marilyn A. Meyers, Economic/Commercial Officer, Embassy of the United States, Tokyo, Japan, June 4, 1976.

Volkwagen and Audi engineering officials say they need more time to develop an engine at a competitive price which can meet Japan's stiff emission control standards and have asked the Japanese Government to postpone implementation of the standard scheduled for 1978.[5/]

United States Exports of Automotive Products

The value of United States exports of automotive products to the world (excluding Canada) in 1975 was nearly three times the value in 1970.[6/] These exports grew from $1,354 million in 1970 to $3,978 million in 1975 for an average rate of growth of 26 percent per year. The shares of cars, trucks and parts of total exports were relatively stable until 1975 when exports of trucks were a larger share of exports and parts were less.

In contrast to the concentration of imports, most of which came from Japan and West Germany, United States export markets are diffuse. Excepting Canada, the three largest U.S. export markets, Mexico, Iran and Venezuela, took 14, 13 and 7 percent repsectively, of total U.S. automotive exports in 1975. Iran emerged as one of the top export markets in 1975 while Mexico and Venezuela have been in the top three since 1965.

The value of United States automotive exports to Mexico, Venezuela and Iran for years 1970 to 1975 are as follows:

5/ The Journal of Commerce, June 17, 1976.

6/ Table 10-3, Appendix.

United States Exports of Automotive Products

(Millions of dollars)

Country of Destination	1970	1971	1972	1973	1974	1975
Mexico	200	200	300	300	500	600
Venezuela	90	90	100	100	200	300
Iran	20	30	40	50	100	500
Total Countries Except Canada	1,400	1,300	1,400	1,800	2,700	4,000

The rate of growth of the export market exceeded the growth of the wholesale price indexes for vehicles indicating a real increase in the size of export markets. The average annual increase in the wholesale price indexes for the period 1970-75 was: cars, 5 percent; trucks, 7 percent; and parts, 8 percent. During that time the average annual increases in the value of United States exports to the world except Canada were: cars, 27 percent; trucks, 58 percent; and parts, 20 percent. The annual rates of growth were low or negative during 1971-1973 but accelerated to very high rates from 1973 to 1975.

The pattern of growth reflected changes in exchange rates which lowered prices of United States exports and a recovery by several countries from depressed economic conditions at the beginning of the period.

With the exception of Canada, each of the industrialized nations which manufactures automobiles (in contrast to auto assembly) imported 6 percent or less of total United States automotive exports in 1975. U.S. parts exports have been about half of total automotive exports and in 1975 Mexico imported 21 percent, Iran 8 percent, and Venezuela 6 percent. The largest suppliers of automotive products to the United States, Japan and West Germany, imported only 2 and 3 percent respectively, of U.S. exports of automotive parts. 7/

Parts are exported either for assembly as original equipment into new vehicles or for replacement and repair of existing vehicles. The U.S. export classification system, (1976 Schedule B) has 65 categories identified as all or mostly automotive parts. Six of these categories are specifically identified as parts for assembly. In 1975 these six codes accounted for $550 million, or almost one-third, of all U.S. automotive parts exports which totaled $1,700 million. A single "basket" category labled "parts, new, for assembly" accounted for $440 million. 8/ Other categories among the total 65 automotive parts categories include an unknown quantity of parts for assembly.

7/ Table 10-4, Appendix

8/ Table 10-5, Appendix

United States Imports of Automotive Products

United States imports of automotive products from all countries except Canada grew rapidly from 1970 to 1974, then leveled out in 1975. The value of those automotive imports was $2.3 billion in 1970 and $5.6 billion in 1975. Passenger cars constituted the biggest part of the imports, their value doubling from $1.9 billion in 1970 to $4.3 billion in 1975. Truck and bus imports, while a much smaller share of the total market than cars or parts, grew at a rapid rate from less than $0.1 billion in 1970 to $0.4 billion in 1975. Parts imports grew a little less than three-fold from $0.3 billion in 1970 to $0.9 billion in 1975. 9/ Since 1970 imported cars have averaged a little less than 16 percent of the United States retail market for automobiles. Prices of imported automobiles have increased more than the prices of North American types in the recent past. The relatively higher costs of imported cars may result in reduced consumer demand and the import share of the U.S. market for the first six months of 1976 is less than 14 percent. Imports are not expected to increase their market share significantly without a shift in price levels and a lowering of the relative prices of imported cars. The large number of imported cars operating in the United States will continue to need repair parts and the importing of parts to service these cars will continue to grow.

9/ Table 10-6, Appendix

Passenger Cars. During the period 1970-1975 passenger car imports into the United States from overseas (excluding Canada) increased 126 percent in terms of value while the number of units imported rose only 1.0 percent. Total passenger car imports rose from 1,320,000 units valued at $1.9 billion in 1970 to 1,341,000 units valued at $4.3 billion in 1975. Japan and West Germany are the largest suppliers and together supplied 78 percent of the passenger cars imported into the United States in 1975.

Japan and Germany plus France, Italy, Sweden, and the United Kingdom supplied 96 percent of the United States market for imported passenger cars in 1975. Imports of cars from the rest of the world were valued at $157 million, or 4 percent of the total, in 1975 compared to $62 million, also 4 percent of the total, in 1970.

Japan. In 1970 the United States imported 381,000 cars worth $457 million from Japan. By 1975 imports from Japan rose to 696,000 cars valued at $1,762 million. During the period Japan replaced West Germany as the supplier of the largest number of imported automobiles to the United States. In 1970 Japan supplied 29 percent of the imported cars and the average value of a car from Japan was $1,200. By 1975 the average value was $2,500 and Japan supplied 52 percent of U.S. imports. 10/

10/ Table 10-7, Appendix

West Germany. In 1970 United States imports of cars from West Germany were 675,000 units worth $1,066 million.

In 1975 imported units declined to 370,000 while their value rose to $1,568 million. 11/ The average value of a car imported from Germany increased from $1,600 in 1970 to $4,100 in 1975 and Germany lost its top position in the U.S. imported car market to Japan. In 1970 Germany supplied 51 percent of the cars imported into the United States but by 1975 the share was down to 26 percent.

Italy. Italy is the third largest overseas supplier of automobiles to the United States market. In spite of the substantial rate of increase of its exports to the United States, Italy supplied only 7 percent of the value of United States automobile imports in 1975. In 1970 the United States imported $64 million worth of cars from Italy and in 1975 the value was $301 million.

Sweden. In 1975 Sweden supplied cars valued at $238 million, or 5 percent of the United States imported car market. In 1970 Sweden had supplied $108 million worth of cars, also about 5 percent of the market. 12/

11/ Table 10-8, Appendix

12/ Table 10-10, Appendix

Antidumping. Imports of automobiles have recently been subject to investigation by the U.S. Treasury Department on charges of antidumping violations. The charges concerned automobiles from Belgium, Canada, France, Italy, Japan, Sweden, the United Kingdom, and West Germany. The investigation was initiated pursuant to two petitions received from a Congressman and the United Auto Workers.

After having conducted a full scale investigation of all major exporters of automobiles from the eight countries, the Treasury tentatively discontinued its work on May 17, 1976, in recognition of certain circumstances unique to the automobile industry.

The extremely long lead times between production, export, and transfer of automobiles, create pricing difficulties as exchange rates fluctuate. This, coupled with the fact that the foreign manufacturer almost invariably has a corporate relationship to, and an extremely heavy financial interest in the importer, makes the problem more serious. During the production-to-transfer time period, changes can occur in the currency exchange rate which could create dumping margins beyond the control of the manufacturer. A strict adherence to traditional policy could require every automobile in the inventory of a U.S. affiliate to bear a different price.

Another unique circumstance relates to the pollution control and safety equipment required for all cars sold in the United States. These requirements differ significantly from those in the home countries of the various manufacturers. Meeting U.S. requirements is extremely expensive on a per-unit basis for a foreign manufacturer if the cost of this required equipment is allocated only to the units sold in the U.S. market, the method called for in antidumping procedures.

Accordingly, these factors were taken into consideration and reflected in certain specialized commitments received from the automobile manufacturers as the basis for discontinuing the investigation.

In the Canadian investigation, particular note was taken of the effect the U.S.-Canadian Auto Agreement has had in the trend toward lower price differences between automobile prices in Canada and the United States.

On August 13, 1976 the United States Treasury Department announced that final determinations had been made in its antidumping investigations of automobile imports. The Treasury Department determined that five firms did not price their automobiles in the United States market during the period under investigation below home market prices for comparable products. The other 23 manufacturers were required

to supply commitments to the Treasury Department, which will monitor their prices for conformance to these commitments over the next two years.

Parts and Components. Those countries which supply imports of motor vehicles to the United States also lead in supplying the U.S. with imports of parts and components. The cars imported from foreign countries are inevitably followed by the importation of parts for replacement. It is possible, however, that some of the parts imported are being used as original equipment on U.S.-built cars. Import statistics do not provide a distinction between the two end-use categories. Therefore, it is not possible to measure parts for assembly and parts for replacement from countries which also supply vehicles. There is little evidence that there is an extensive import trade in original equipment parts, although it is likely that accessories account for a substantial portion of the trade from some countries (e.g., radios from Brazil).

United States imports of automotive parts and components from all countries except Canada rose steadily from $324 million in 1970 to $1,049 million in 1974 and then declined to $924 million in 1975. 13/ In 1975 imports of parts and components from Brazil, Mexico and Spain accounted for $195 million out of a total of $872 million for the ten countries

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13/ Table 10-20, Appendix

listed in the following table. A portion of this trade can be original equipment, as these countries do produce vehicles. Mexico is the third largest supplier of parts, following Japan and West Germany. The two largest suppliers of automotive parts (57 percent), Japan and West Germany, also supplied the largest numbers of automobiles (78 percent) in 1975. The three largest suppliers accounted for 70 percent of total imports of parts (excluding Canada).

In the following table, which includes only parts imports, four of the countries listed, Australia, Brazil, Spain and Mexico, do not export motor vehicles to the United States in any volume. Both Australia and Spain have low ranking parts volumes (10th and 9th, respectively). Brazil and Mexico have higher volumes because of unique situations. Neither Brazil's nor Mexico's trade volumes are directly related to the customary flow of spare parts supplied by original vehicle or equipment manufacturers following the vehicle trade. Producers in these two countries are supplying to the U.S. original equipment parts or aftermarket service parts, primarily to obtain credit against local content requirements.

United States Imports of Automotive Parts, 1975

Country of Origin	Million of Dollars
Japan	327
West Germany	203
Mexico	122
United Kingdom	62
Brazil	62
France	46
Italy	23
Sweden	15
Spain	12
Australia	1

Parts imports 1970 to 1975 by TSUSA category total from all countries (excluding Canada) and by country from Japan, West Germany, Mexico, United Kingdom, France, Italy, Sweden, and Brazil are shown in the statistical appendix. 14/

World Patterns of Automotive Production and Trade

Two developments in world trade in recent years are the "international car" and "complementation" in parts and components. The names are relatively new in usage, and basically reflect the most recent stage of growth in automotive production and trade and the continuing effort to obtain more efficient methods. These concepts typically work in free trade areas which foster integration of automotive production and trade,

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14/ Tables 10-11 to 10-19, Appendix

although the international car and complementation are developing in the world at large, trade barriers permitting.

Basically an international car is the same or similar model produced in two or more countries by the same motor vehicle manufacturing company (a multinational company). Correspondingly, complementation in parts and components is the practice of a multinational company of producing or buying a particular part or component in one country for assembly into cars in one or more other countries. Parts and components for a given model might be produced in a number of different countries based upon the usual "make or buy" considerations.

These practices and related procedures are described more fully below. The impact upon the U.S. market in the case of the international car probably is no different than that of any individual model being imported, although the manufacturing company would have a choice between importing the model and producing it in the United States. In the case of complementation, there is some evidence of an increase in U.S. imports of parts and components for original equipment in the production of vehicles. However, it cannot be measured precisely and in any event it is of a low order of magnitude.

The International Car. Building the "international car" allows a standardization of production procedures and other economies including (1) greater assembly efficiency, (2) cost reductions because of larger volume production runs for standardized components, (3) reduced inventories of replacement parts for the after-market, and (4) standardized training of service maintenance and repair personnel.

Ford Motor Company and General Motors Corporation have had extensive experience in production of international cars and Chrysler Corporation plans to introduce new, front wheel drive sub-compact models in model year 1978, which will be Chrysler's first domestically-produced sub-compact cars.

General Motors' Chevrolet "Impala" is being assembled in Venezuela and Mexico. The model "Kadett" manufactured in West Germany is similar to the Chevette. The "Gemini" is assembled in Japan (Isuzu) and Australia, and the "Opel K180" in Argentina. Both have specifications similar to the German-built "Kadett". The "Cavalier" also copies the Opel and is built in Belgium for sale exclusively in the United Kingdom.

The Chevette is a world car, and it marks the first major integration of overseas and domestic product lines in General Motors.

GM's objective was to standardize worldwide design and production as much as possible and thereby save money in a time of high tooling costs. The result was a considerable standardization of appearance and general characteristics - a kind of global automotive homogenization.

The world car varies from country to country. On the U.S. version, for instance, added bumper reinforcements (specified by Federal regulations) add about 45 pounds to the car's weight.

The introduction of the Chevette, or the T-car as it was called while under development, marked the first appearance of GM's world car in the North American market. It also is sold in Canada as the Acadian.

The T-car is already being produced in six countries in three major sectors of the world. The first model was introduced in Brazil in mid-1973. Later versions were produced and sold in West Germany, Japan, Britain and Australia under the names Kadett, Gemini and Chevette. Bringing the T-car to the U.S. market meant redesigning its entire power train to conform to American roads, pollution and safety regulations and driving habits.

Production of the Ford Motor Company's model "Fiesta" was initiated in 1976 in Valencia, Spain, Saarlouis, Germany and in England. This model is also planned for production in the United States in the future. Ford's model "Capri" is produced in Germany, England, and Portugal. A small commercial vehicle called the "Fiera" is being built in seven body configurations in Thailand, Taiwan, and the Philippines.

The Escort, for example, is produced or assembled in the United Kingdom, Germany, South Africa, Australia, Ireland, Netherlands, Protugal, New Zealand, Philippines, Singapore, Taiwan and Thailand, and the Maverick is produced in the United States, Canada, Brazil, Mexico and Venezuela.

The Fiesta was approved for production in December 1973. It was planned and engineered for the European market and aimed at the under 2,000-pound segment. This segment accounted for 20 percent of all European sales in 1973 and it has now grown to nearly 26 percent. In some countries, such as Italy, it represents one in every two passenger cars now sold. Ford plans to introduce the Fiesta in the U.S. at the beginning of the 1978 model year and estimate that first year imports will be about 100,000. This relatively modest program will provide a test of the American public's interest in cars of this size. The possibility of eventually manufacturing or assembling the Fiesta in the U.S. will be determined by public acceptance.

Because of the car's unique design, Ford estimates that domestic production would require a $1 billion investment for development, tooling and facilities.

Complementation in Parts and Components. There is considerable overlap in the usage and significance of the international car and complementation just as it is extremely difficult to consider the automobile, per se, without taking into account the parts and components 17/ with which it is made. Even more difficult, if not impossible, is to structure a system of parts and components production and trade without a constant reference to the completed vehicle and related factors of business decision. Nevertheless, complementation does embrace an approach to procurement, and related activities such as engineering, in producing cars in various countries of the world.

Complementation is designed to pool the resources of various country groupings (especially free trade areas) so that both standardization and economies of scale result. National rivalries have emerged, however, especially in the Andean group. Each nation, no matter how irrationally, wants an assembly plant primarily instead of facilities that produce parts and components.

17/ As discussed earlier, the terms parts and components are virtually interchangeable in general, and specific usage depends upon both the item and custom. The use of one term alone may infer that the other is intentionally omitted.

It is becoming increasingly effective to standardize the design of components and to engineer the components into as many different models as possible regardless of the country of origin of the complete vehicle. Ford Motor Company 18/ refers to this standardization of design and usage as "complementation." Ford of Mexico sends engines to Venezuela and engine blocks to the United States while Ford of Brazil ships cams and crankshafts to Argentina, which ships back rocker arms. Ford of New Zealand exchanges chassis parts on a value basis for vehicles manufactured by Ford of Australia.

Similarly, "Vauxhall (General Motors in England) has reinforced the success of its Chevette 3-door hatch-back with 2-door and 4-door hatch-back sedans. The cars use Opel Kadette body pressings and the Chevette streamlined front, plus Vauxhall engines and drive trains."19/

The term "complementation" also is used below in connection with the operation of the Andean Group but under somewhat different circumstances. In this instance, the governments involved appear to establish the complementation.

18/ "Ford: A Global Corporation", Ford Motor Corporation, 1972.
19/ Ward's Automotive Reports, June 21, 1976.

There are three major country groupings which involve the complementation process; the European Economic Community (EEC), the Latin American Free Trade Association (LAFTA) and the Andean Sub-regional Group.

Intra-community trade in motor vehicles in 1974 amounted to over 1.5 million vehicles in the EEC. This figure (total vehicle imports) is subject to inflating by the double-counting implicit in international motor vehicle trade figures. For example, West Germany reports shipment of thousands of vehicles in knocked-down form to Belgium, where they are assembled and reported again as completed vehicles by Belgium. However, the total probably is not inflated by more than 10 percent.

The tendency of this type of free trading agreement is toward reductions in the number of vehicle models each member-nation produces, with a view to increased economies of scale in production for more rationalized markets. This tendency will be increased as the markets of the United Kingdom, Denmark and Ireland (443,000 vehicles produced in 1974) are added to the free-trade total in July 1977.

LAFTA was organized in 1961, (Argentina, Brazil, Chile, Mexico, Paraguay, Peru and Uruguay) and expanded by accession (Columbia, September 1961, Ecuador November 1961, Venezuela August 1966, and Bolivia February 8, 1967). The Association's main objective is the increase of mutual trade and economic growth of the members through the progressive reduction or elimination of tariffs on each other's products.

The mechanics of trade liberalization employed by LAFTA--National Lists, the Common List, and Complementation Agreements--have been used on a "product-by-product" basis in contrast to the "across the board" approach used by the EEC.

The Andean Subregional Group was created October 16, 1969 by Bolivia, Chile, Colombia, Ecuador, and Peru and joined by Venezuela February 13, 1973. The group was formed within the existing LAFTA structure to enable the member countries to compete on a more nearly equal basis with the LAFTA big three, Argentina, Brazil, and Mexico, in advancing the process of economic integration among member countries.

Table 2-1

Distribution of trips by persons in each age group, classified by major mode of transportation (all persons by mode).

Age group	Major mode of transportation													Total annual trips
	Auto driver	Auto passenger	Subtotal-automobile	Taxicab	Motorcycle	Truck	School bus	Other bus	Elevated or subway	Other train	Airplane	Other	Total	Base of percentages (millions)
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	
5-13	-	72.0	72.0	0.2	-	3.4	22.3	1.6	0.1	-	-	0.4	100.0	21,020
14-15	4.6	63.2	67.8	0.2	0.4	4.1	21.2	5.2	0.6	-	-	0.5	100.0	5,271
16-20	49.2	36.7	85.9	-	0.6	2.7	5.5	4.0	1.0	0.2	-	0.1	100.0	15,527
21-25	62.1	29.1	91.2	0.3	0.5	3.8	0.6	2.6	0.6	0.2	-	0.2	100.0	14,652
26-29	67.9	22.5	90.4	0.4	0.1	5.0	0.3	2.6	1.0	-	0.1	0.1	100.0	10,046
30-39	70.0	19.3	89.3	0.3	-	7.3	0.5	1.7	0.5	0.1	0.1	0.2	100.0	23,985
40-49	66.0	21.5	87.5	0.2	0.1	8.0	0.5	2.5	0.8	0.2	0.1	0.1	100.0	24,070
50-59	62.8	24.6	87.4	0.3	-	7.4	0.5	2.9	1.0	0.2	0.1	0.2	100.0	16,685
60-64	58.2	26.1	84.3	0.7	-	7.4	0.4	4.6	1.7	0.6	-	0.3	100.0	6,391
65-69	57.6	29.2	86.8	0.8	-	6.4	0.5	4.6	0.6	-	0.1	0.2	100.0	3,236
70 and over	50.2	41.0	91.2	0.4	-	2.6	0.7	4.0	0.5	0.2	0.2	0.2	100.0	4,263
Total	51.4	33.7	85.1	0.3	0.2	5.6	4.9	2.7	0.7	0.2	0.1	0.2	100.0	145,146

Source: Based upon unpublished table P-1 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for the Federal Highway Administration, 1969-1970.

TABLE 2-2

Intercity Travel by Mode, 1960, 1965-1973

Year	Motor Vehicle 1/	Railroad	Airline 2/	Inland Waterways	Total
Passenger miles (billions)					
1973	1199.6	9.0	141.0	4.0	1353.9
1972	1154.6	8.7	133.0	4.0	1300.3
1971	1096.5	8.9	119.9	4.1	1229.4
1970	1051.3	10.9	118.6	4.0	1184.8
1969	1001.9	12.3	119.9	3.8	1137.9
1968	960.9	13.3	101.2	3.5	1078.9
1967	914.7	15.3	87.2	3.4	1020.6
1966	881.0	17.3	69.4	3.4	971.0
1965	841.4	17.6	58.1	3.1	920.2
1960	726.0	21.6	34.0	2.7	784.3
Passenger miles (percent)					
1973	88.6	0.7	10.4	0.3	100.0 3/
1972	86.8	0.7	10.2	0.3	100.0
1971	89.2	0.7	9.8	0.3	100.0
1970	88.7	0.9	10.0	0.3	100.0
1969	88.0	1.1	10.5	0.3	100.0
1968	89.1	1.2	9.4	0.3	100.0
1967	89.6	1.5	8.5	0.3	100.0
1966	90.7	1.8	7.1	0.3	100.0
1965	91.8	1.8	6.0	0.3	100.0
1960	92.6	2.7	4.3	0.3	100.0

1/ Includes intra-city parts of intercity trips.

2/ Domestic revenue service only.

3/ Details may not total 100 because of rounding.

Source: Interstate Commerce Commission and Transportation Association of America.

Table 3-1

Employment in motor vehicle manufacturing compared to total nonagriculture, manufacturing and durable goods manufacturing employment, 1965-75.

	Total, private industry except agriculture	Manufacturing	Durable goods manufacturing	Motor vehicle manufacturing	Motor vehicle employment as a percent of		
					Total, private industry except agriculture (000's)	Manufacturing	Durable goods manufacturing
	(000's)	(000's)	(000's)	(000's)			
1965	60,815	18,062	10,406	842.7	1.39	4.67	8.10
1966	63,955	19,214	11,284	861.6	1.35	4.48	7.64
1967	65,857	19,447	11,439	815.8	1.24	4.19	7.13
1968	67,951	19,781	11,626	873.7	1.29	4.42	7.52
1969	70,442	20,167	11,895	911.4	1.29	4.52	7.66
1970	70,920	19,349	11,195	797.3	1.12	4.12	7.12
1971	71,222	18,572	10,597	842.6	1.18	4.54	7.98
1972	73,714	19,090	11,006	862.8	1.17	4.52	7.84
1973	76,896	20,068	11,839	955.3	1.24	4.76	8.07
1974	78,413	20,046	11,895	890.8	1.14	4.44	7.49
1975	76,985	18,347	10,679	774.1	1.01	4.22	7.25

Source: Bureau of Labor Statistics, survey of payroll employment in nonagricultural establishments as reported in Employment and Earnings.

Table 3-2

Production worker weekly hours and earnings, motor vehicle manufacturing, 1965-75.

	Average hourly earnings (dollars)	Average weekly earnings (dollars)	Average weekly hours
1965	3.34	147.63	44.2
1966	3.44	147.23	42.8
1967	3.55	144.84	40.8
1968	3.90	168.09	43.1
1969	4.10	170.56	41.6
1970	4.22	170.07	40.3
1971	4.72	194.46	41.2
1972	5.12	220.16	43.0
1973	5.46	237.51	43.5
1974	5.90	239.54	40.6
1975	6.47	262.63	40.6

Source: Bureau of Labor Statistics, survey of payroll employment in nonagricultural establishments as reported in <u>Employment and Earnings</u>.

Table 3-3

Indexes of occupational wage relationships, selected jobs, motor vehicle establishments

(Average hourly earnings for janitors in each year = 100)

Occupation	1973	1969	1963	1957	1950
Patternmakers, wood and metal-------	148	161	162	164	154
Tool and die makers	136	146	144	143	115
Machine-tool operators, toolroom--------	132	141	138	136	138
Electricians-------	133	141	137	136	135
Pipefitters--------	130	138	134	133	132
Millwrights--------	130	138	134	133	131
Carpenters---------	129	137	133	132	131
Punch-press operators	107	107	110	111	119
Assemblers 1/------	106	107	109	110	116
Truckers, power----	105	106	108	108	111
Laborers, material handling--------	104	105	106	105	108

1/ Data relate to line and bench assemblers in 1950, 1957, and 1963, and to major and minor assemblees in 1969 and 1973.

Source: Bureau of Labor Statistics

Table 3-4

Major occupational groups as a percent of total employment in motor vehicle manufacturing, 1960 and 1974.

Major Occupational Group	1960 Ratio	1974 Ratio
Total	100.00	100.00
White collar workers	19.61	21.68
Professional, technical and kindred workers	6.29	7.80
Managers, officials, proprietors	2.75	3.44
Sales workers	.75	.81
Clerical workers	9.82	9.63
Blue collar workers	78.27	75.88
Craftsmen, foremen, kindred workers	22.74	19.61
Operatives	51.84	52.24
Laborers, nonfarm	3.69	4.03
Service workers	2.15	2.43

Source: Bureau of Labor Statistics Industry - Occupational Matrix

Table 4-1

Motor Vehicle Production - 1975
U. S. Plants

Passenger Car Production

AMERICAN MOTORS CORP.	
Gremlin	51,471
Hornet	69,557
Pacer	140,996
Matador	61,772
Total American Motors Corp.	323,796
CHRYSLER CORP.	
Valiant	215,761
Volare	33,416
Fury	122,703
Gran Fury	71,670
Total Plymouth	443,550
Chrysler	102,940
Imperial	1,930
Total Chrysler-Plymouth	548,420
Dart	203,473
Aspen	25,129
Coronet	72,417
Dodge	53,463
Total Dodge	354,482
Total Chrysler Corp.	902,902
FORD MOTOR CO.	
Ford	191,405
Torino	153,510
Elite	90,738
Club Wagon	34,639
Granada	336,864
Maverick	105,418
Pinto	163,510
Mustang	187,554
Thunderbird	37,776
Total Ford	1,301,414
Mercury	79,507
Montego	52,751
Cougar	57,215
Monarch	108,103
Comet	46,822
Bobcat	60,706
Total Mercury	405,104
Lincoln	55,499
Mark IV	46,021
Total Lincoln	101,520
Total Lincoln-Mercury	506,624
Total Ford Motor Co.	1,808,038

Table 4-1 (con't)

GENERAL MOTORS CORP.	
Chevrolet	318,405
Corvette	45,961
Monte Carlo	266,578
Chevelle	246,722
Camaro	156,400
Nova	296,416
Vega	193,247
Monza Notchback	82,954
Chevette	80,394
Total Chevrolet	1,687,077
Pontiac	104,073
Grand Prix	112,896
Le Mans	88,364
Firebird	94,198
Ventura	60,404
Astre	55,805
Sunbird	7,728
Total Pontiac	523,468
Oldsmobile	226,845
Toronado	22,535
Cutlass	363,814
Omega	37,410
Starfire	3,887
Total Oldsmobile	654,491
Buick	227,732
Riviera	16,759
Century	212,948
Apolio/Skylark	74,443
Skyhawk	3,938
Total Buick	535,820
Cadillac	193,444
Eldorado	48,134
Seville	36,826
Total Cadillac	278,404
Total General Motors Corp.	3,679,260
CHECKER MOTOR CORP.	3,181
TOTAL PASSENGER CARS	6,717,177

Table 4-1 (con't)

Truck and Bus Production

Chevrolet	773,236
GMC	197,034
Diamond Reo	543
Dodge*	319,694
Ford	692,200
International	101,872
Jeep Corp.	139,906
Mack	24,629
White	11,793
Others	11,101
TOTAL TRUCKS AND BUSES	2,272,008
TOTAL PASSENGER CARS	6,717,177
TOTAL MOTOR VEHICLES	8,989,185

Motor Vehicle Manufacturers Association, January 5, 1976

TABLE 4-2

Original-equipment motor-vehicle parts: U.S. production, by class of producer, in terms of transfer values, 1960-74, January-June 1974, and January-June 1975

Period	Motor vehicle manufacturers	Independent parts producers	Total	Independents as a percent of the total
	Million U.S. dollars	Million U.S. dollars	Million U.S. dollars	Percent
1960	4,718	4,374	9,092	48.1
1961	5,678	4,488	10,166	44.1
1962	7,065	5,589	12,654	44.2
1963	8,209	6,353	14,562	43.6
1964	8,465	6,629	15,094	43.9
1965	10,839	8,628	19,467	44.3
1966	10,645	8,247	18,892	43.7
1967	9,461	7,347	16,808	43.7
1968	11,222	8,242	19,464	42.3
1969	11,973	8,791	20,764	42.3
1970	9,472	7,586	17,058	44.5
1971	13,037	9,421	22,458	41.9
1972	13,799	10,454	24,253	43.1
1973	16,002	13,233	29,235	45.3
1974	16,176	12,962	29,138	44.5
1974:				
January-June	7,492	6,056	13,548	44.7
1975:				
January-June	7,807	7,363	15,170	48.5

Source: United States International Trade Commission.

Table 4-3

United States - Canada Trade Automotive Products, 1964, 1969-75
U. S. Imports - Canadian Imports

Millions of U. S. Dollars

	1964	1969	1970	1971	1972	1973	1974	1975
U. S. exports 1/								
Cars	34	732	631	985	1,075	1,439	1,657	2,142
Trucks	23	244	263	334	504	643	916	922
Parts	577	2,134	2,019	2,448	2,866	3,552	3,980	4,409
Sub total	634	3,110	2,913	3,767	4,445	5,634	6,554	7,472
Tires and tubes	6	34	23	36	51	92	223	170
Total exports	640	3,144	2,936	3,803	4,496	5,726	6,777	7,643
U. S. imports								
Cars	18	1,537	1,474	1,924	2,065	2,272	2,595	2,809
Trucks	4	560	564	587	713	789	887	917
Parts	49	959	1,080	1,481	1,795	2,172	1,997	2,008
Sub total	71	3,056	3,118	3,992	4,573	5,233	5,479	5,734
Tires and tubes	5	5	14	8	22	68	65	67
Total imports	76	3,061	3,132	4,000	4,595	5,301	5,544	5,801
Net balance	+563	+83	-196	-197	-99	+426	+1,233	+1,842

1/ Canadian import data. Parts exports (Canadian imports) adjusted to exclude tooling charges in millions of U.S. dollars as follows: 1969-\$75; 1970-\$98; 1971-\$68. 1972-\$85; 1973-\$68; 1974-\$128; 1975-\$38.

Note: Data exclude U.S.-Canadian trade in materials for use in the manufacture of automotive parts.

Data are adjusted to reflect transaction values for vehicles.
\$1.00 Canadian = \$0.925 U.S., 1964-69; \$0.958 U.S., 1970; \$0.990 U.S., 1971; \$1.009 U.S., 1972; \$0.9997 U.S., 1973; \$1.02246, U.S., 1974; \$.984001, U.S. 1975.

Source: U.S. Department of Commerce

Table 4-4

U.S. Imports from Canada and Consumption
of Original Equipment Parts
(Millions of dollars)

Year	U.S. Imports from Canada: Motor Vehicle Manufacturers	U.S. Imports from Canada: Independent Parts Producers	Total	Total U.S. Consumption
1966	$ 194	$ 108	$ 302	$18,283
1967	228	163	391	16,170
1968	343	313	656	18,696
1969	383	412	795	19,804
1970	440	480	920	16,206
1971	636	577	1,213	21,607
1972	781	723	1,504	23,853
1973	816	915	1,731	28,118
1974	744	819	1,563	27,217
1975[a]	700	800	1,500	28,000

a/ Estimated by BDC

Source: International Trade Commission

Table 4-5

U.S. Exports to Canada and Canadian Consumption
of Original Equipment Parts
(Millions of Canadian Dollars)

Year	U.S. Imports to Canada: Motor Vehicle Manufacturers	U.S. Imports to Canada: Independent Parts Producers	Total Canadian Consumption
1966	$ 526	$ 281	$1,479
1967	552	305	1,626
1968	791	407	2,153
1969	1,103	488	2,495
1970	901	506	2,096
1971	1,096	484	2,414
1972	1,272	563	2,683
1973	1,516	760	3,114
1974	1,859	862	3,686
1975a/	2,077	1,047	4,231

a/ Based on 6 months extrapolation

Source: Department of Industry, Trade and Commerce, Canada

Table 8-1

U.S. Retail Sales of Automobiles 1970-76

(Millions of Units)

Year	North American Built	Overseas Imports	Total
1970	7.1	1.3	8.4
1971	8.7	1.6	10.3
1972	9.3	1.6	10.9
1973	9.7	1.8	11.5
1974	7.5	1.4	8.9
1975	7.0	1.6	8.6
1976 1/	8.8	1.5	10.3

1/ Estimated by Bureau of Domestic Commerce

SOURCE: Motor Vehicle Manufacturers Association of the United States

Table 8-2

Privately Registered Automobiles in the United States 1960-1975

Thousands of Units

1960	61,431
1961	63,153
1962	65,825
1963	68,756
1964	71,664
1965	74,903
1966	77,751
1967	80,014
1968	83,175
1969	86,408
1970	88,762
1971	92,257
1972	96,451
1973	101,189
1974	104,230
1975*	106,300

* Estimated

Source: Federal Highway Administration

Table 8-3

U.S. New Car Deliveries by Classes-1970-1975

(Percent of total U.S. market)

Classes	1970	1971	1972	1973	1974	1975
Domestic						
Sub-Compact	1.8	7.4	8.2	9.4	8.9	8.1
Compact	13.4	11.4	12.3	14.0	17.4	18.7
Sport	6.5	4.3	2.8	3.9	6.8	7.7
Passenger Van	0.6	0.6	0.7	0.8	1.0	1.2
Intermediate	22.2	19.6	21.2	21.6	22.7	22.1
Regular	34.1	33.4	31.8	29.3	21.9	17.9
High	6.2	8.1	8.2	5.6	5.3	5.9
Imports	15.2	15.2	14.8	15.4	15.9	18.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Motor Vehicle Manufacturers Association of the U.S., Inc.

Table 8-4

Summary of Alternative Automobile Market Classifications

Source	Market Classes	How Defined	Comments
TSC	3 Small, Medium and Large	Weight	Annual percentage shares, 1957-1973
FEA	5 Three Domestic and Two Imports	Weight and Horsepower	Classification not available yet
Aerospace	5 Standard, Intermediate, Compact, Subcompact and Specialty	Wheelbase	Data available for 1958, 1960, 1966, 1970, and 1972
Chase	5 Luxury, Standard, Intermediate, Compact and Subcompact	Wheelbase and Price	Interpolated Aerospace data to provide annual series, 1958-72
Chamberlain	5 Compact and Subcompact, Intermediate, Full Size, High Price Full Size Specialty, and Luxury	Price - Polk Price Classes	
MVMA	8 Domestic - Subcompact, Compact, Sport, Passenger Van, Intermediate, Regular, High Price, and Imports	Judgment based on wheelbase, price and weight	Annual shares, 1968-74
Ward's	8 Domestic - Subcompact, Compact, Intermediate, Specialty/Sports Type, Regular Size, Medium Price, High Price and Imports	Judgment based on wheelbase, price, and weight	Annual shares, 1965-73
Automotive News	8 Domestic - Subcompact, Compact, Luxury Small, Intermediate, Low Standard, High Standard, Luxury Standard, and Imports	Judgment based on wheelbase, price, and weight	Annual shares, 1973-74. Delineations of market classes keep changing

Source: Interagency Task Force on Motor Vehicle Goals Beyond 1980 (Marketing and Mobility Panel); March, 1976.

Table 8-5

Wholesale Price Indexes Automobiles, and Consumer Price Indexes, New Passenger Cars and All Consumer Items Total Manufactures 1970-1975

(1967 = 100)

	Wholesale Price Indexes		Consumer Price Indexes	
Year	Passenger Cars	Total Manufactures	New Passenger Cars	All Consumer Items
1970	106.6	110.2	107.6	113.3
1971	112.2	113.8	112.0	119.2
1972	114.9	117.9	111.0	123.2
1973	115.4	129.2	111.1	127.7
1974	123.1	154.1	117.5	139.7
1975	132.2	171.1	127.6	156.1

SOURCE: U. S. Department of Labor

Table 9-1

Balance Sheet and Income Statement Items, Corporations
Included in Motor Vehicle Industry, 1969-1975

(millions of dollars)

	1969	1970	1971	1972	1973	1974	1975	1969-1975
Balance Sheeet 1/								Change
Depreciable fixed assets	28,557	30,996	32,581	33,694	35,637	29,229	31,755	3,198
Long-term debt	2,623	3,207	4,160	4,674	4,808	4,276	6,048	3,425
Capital stock	4,859	5,004	5,102	5,193	5,125	5,368	5,745	886
Retained earnings	17,974	17,889	19,116	20,931	22,262	21,651	22,768	4,794
Income Statement 2/								Total
Depreciation allowances	1,628	1,764	2,037	3,018	3,217	2,557	3,003	17,224
Income after taxes	2,845	1,424	3,097	3,697	4,083	1,863	1,737	18,746

1/ Amounts at end of fourth quarter.

2/ Amounts are sums of four quarters.

Source: Quarterly Financial Reports, Federal Trade Commission

Table 10-1 OUTPUT PER HOUR, OUTPUT, AND TOTAL HOURS
ALL EMPLOYEES IN THE MOTOR VEHICLE INDUSTRY, 1965-1974

(INDEXES: 1967=100)

YEAR	UNITED STATES	JAPAN (1)	GERMANY	ITALY (1)	UNITED KINGDOM
OUTPUT PER HOUR					
1965	99.0	76.5	99.5	87.4	101.1
1966	99.5	84.2	103.6	95.0	107.4
1967	100.0	100.0	100.0	100.0	100.0
1968	108.3	113.7	110.7	104.2	109.1
1969	106.4	134.1	120.1	(2) 94.1	110.0
1970	102.0	161.2	120.1	(2)132.8	110.2
1971	119.0	178.1	122.9	130.1	114.1
1972	123.9	202.3	131.8	133.3	115.9
1973	126.3	223.0	139.1	136.2	112.6
1974	120.8	212.3	133.1	(3)	107.3
OUTPUT					
1965	109.3	62.7	113.9	72.0	107.0
1966	109.7	75.7	118.0	85.5	105.6
1967	100.0	100.0	100.0	100.0	100.0
1968	121.6	128.2	122.6	111.1	111.6
1969	121.2	151.3	148.0	(2)106.5	118.3
1970	98.3	178.7	163.7	(2)127.5	119.3
1971	123.4	197.9	166.8	123.4	119.9
1972	136.9	214.5	168.4	126.0	122.0
1973	156.4	246.8	182.0	138.5	124.8
1974	131.3	233.8	157.1	130.8	114.0
TOTAL HOURS (4)					
1965	110.4	81.9	114.5	82.3	105.9
1966	110.2	89.9	113.9	90.0	98.3
1967	100.0	100.0	100.0	100.0	100.0
1968	112.3	112.7	110.7	106.6	102.3
1969	113.9	112.9	123.2	(2)113.2	107.5
1970	96.4	110.9	136.3	(2) 96.0	108.3
1971	103.7	111.1	135.6	94.9	105.1
1972	110.5	106.0	127.8	94.5	105.2
1973	123.8	110.7	130.8	101.7	110.8
1974	108.7	110.1	118.0	(3)	106.2

Table 10-2 OUTPUT PER HOUR, OUTPUT, AND TOTAL HOURS
ALL EMPLOYEES IN THE MOTOR VEHICLE INDUSTRY, 1965-1974

(AVERAGE ANNUAL PERCENT CHANGE)

YEAR	UNITED STATES	JAPAN (1)	GERMANY	ITALY (1)	UNITED KINGDOM
		OUTPUT PER HOUR			
1965-74	2.9	13.6	3.9	(5) 6.1	1.1
1965-70	1.2	16.2	4.3	6.2	1.7
1970-74	4.1	8.1	3.4	(5) 1.0	-.7
1965-66	0.5	10.0	4.2	8.6	6.3
1966-67	.5	18.8	-3.5	5.3	-6.9
1967-68	8.3	13.7	10.7	4.2	9.1
1968-69	-1.8	17.9	8.5	(2)-9.7	.9
1969-70	-4.1	20.2	.0	(2)41.1	.2
1970-71	16.7	10.5	2.4	-2.0	3.5
1971-72	4.1	13.6	7.2	2.4	1.6
1972-73	1.9	10.2	5.6	2.2	-2.8
1973-74	-4.4	-4.8	-4.3	(3)	-4.7
		OUTPUT			
1965-74	3.4	16.6	6.0	6.5	1.8
1965-70	-.1	24.1	8.0	10.9	2.9
1970-74	8.5	7.9	.1	1.7	-.5
1965-66	0.4	20.7	3.6	18.7	-1.3
1966-67	-8.8	32.1	-15.3	17.0	-5.3
1967-68	21.6	28.2	22.6	11.1	11.6
1968-69	-.3	18.1	20.7	(2)-4.2	6.0
1969-70	-18.9	18.1	10.6	(2)19.7	.9
1970-71	25.5	10.7	1.9	-3.2	.5
1971-72	10.9	8.4	1.0	2.1	1.7
1972-73	14.2	15.1	8.1	9.9	2.3
1973-74	-16.0	-5.3	-13.7	-5.5	-8.7
		TOTAL HOURS (4)			
1965-74	0.5	2.7	- 1.9	(5) 1.3	0.7
1965-70	-1.3	6.8	3.5	4.4	1.2
1970-74	4.3	-.2	-3.2	(5) 1.7	.1
1965-66	-0.2	9.8	-0.5	9.3	-7.2
1966-67	-9.3	11.2	-12.2	11.1	1.7
1967-68	12.3	12.7	10.7	6.6	2.3
1968-69	1.4	.1	11.3	(2) 6.1	5.1
1969-70	-15.4	-1.8	10.7	(2)-15.1	.7
1970-71	7.6	.2	-.5	-1.2	-2.9
1971-72	6.6	-4.6	-5.8	-.4	.1
1972-73	12.0	4.4	2.4	7.5	5.3
1973-74	-12.2	-.5	-9.8	(3)	-4.2

Footnotes and General Note, Tables 10-1 and 10-2

1/ Production indexes linked at 1970. Italian index also linked at 1966.

2/ Estimates for 1969 and 1970 affected by significant strike activity in the second half of 1969.

3/ Not available.

4/ Hours paid for the United States, hours worked for the other countries.

5/ Period ending in 1973.

Note: The U.S. data apply to SIC 371, which covers passenger vehicles, trucks, and their parts and accessories. Series for the other countries were chosen to correspond as closely as possible to the U.S. industry definition, but there are some significant differences in industry coverage. The series for Germany include motorcycles and bicycles. The series for Japan include motorcycles beginning in 1970 and cover all transportation equipment except railroad equipment and shipbuilding for the period ending in 1970. There are also differences among the countries in the methods of measuring output trends and in the coverage of the hours data. The following are brief descriptions of the data for each country.

United States

Industry definition: Motor vehicles and equipment.

Output: Output indexes for motor vehicles and parts, truck and bus bodies, and truck trailers are combined with 1963 all-employee aggregate hours weights for 1965-67, 1967 hours weights for 1967-72, and 1972 hours weights for 1972 forward. Sub-indexes are combined using value of shipments or value of production weights. Trend indexes are based on deflated values and quantity indicators.

Hours: Hours are paid hours of all employees, with separate estimates of average hours for production and non-production workers. The data relate to establishments of all sizes.

Japan

Industry definition: Motor vehicles and equipment, including motorcycles, for 1970 forward, and all transportation equipment except railroad equipment and shipbuilding, but including industrial vehicles for 1965-70.

Output: Component series are combined using value added at factor cost as weights. Indexes on a 1970 weight base have been linked to indexes on a 1965 weight base as of 1970. Trend indexes are based on quantity indicators obtained from establishments with 50 or more workers.

Hours: Index of the total number of days worked by regular employees in the same establishments from which the output indexes are obtained, adjusted by an index of average hours worked per day by regular employees in establishments employing 30 regular employees or more. No adjustment has been made for contract workers. Indexes on a 1970 base have been linked with indexes on a 1965 base as of 1970.

Germany

Industry definition: Motor vehicles and equipment, motorcycles, and bicycles.

Output: Component series are combined using census value added at 1970 factor cost as weights. Trend indexes are based on quantity indicators obtained from establishments with 10 or more employees. Establishments with less than 10 employees, however, are included in the weighting.

Hours: Hours worked by all employees and self-employed workers in establishments with 10 or more employees. Salaried employees and self-employed workers are assumed to work the same average hours as wage workers. The employment figures are on a product basis; average hours on an establishment basis.

Italy

Industry definition: Motor vehicles and equipment.

Output: Component series are combined using value added weights. Indexes on a 1970 weight base have been linked at 1970 to an index with a 1965 weight base (1966=100) and also linked at 1966 to an index with a 1953 weight base. Trend indexes are based on quantity indicators.

Hours: Hours worked by all employees in establishment with 10 or more employees. Salaried employees are assumed to work the same average hours as wage workers. Average hours worked are an average for the year, whereas the number of employees are average end-of-quarter figures.

United Kingdom

Industry definition: Motor vehicles and equipment.

Output: Component series are combined using weights based on the contribution to gross domestic product at factor cost in 1970. Trend indexes are based on deflated values and quantity indicators.

Hours: Hours worked by all employees. Salaried employees are assumed to work the same average hours as wage workers. The trend in average hours is based on data for October of each year, whereas the employment figures are annual estimates. The data relate to establishments of all sizes.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Table 10-3

United States Exports of Motor Vehicles, Parts and Components (excluding Canada) 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	210.7	236.7	245.4	386.3	564.1	685.7
Trucks, Buses and Special Purpose Vehicles	411.9	362.1	317.0	407.5	652.0	1561.1
Total Vehicles	622.6	598.7	562.4	793.8	1216.1	2246.8
Parts and Components	731.0	722.0	796.7	1013.7	1471.8	1731.6
Total Vehicles, Parts & Components	1353.6	1320.7	1807.5	1807.5	2687.9	3978.4

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

Source: Bureau of Census.

Table 10-4

United States Exports of Automotive Parts and Components to Selected Countries and the World (excludes Canada) 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975
Australia	67.5	55.6	51.3	80.7	125.3	101.9
Belgium	31.3	27.1	26.2	36.4	52.7	63.7
Colombia	31.8	21.4	25.3	28.4	40.2	48.9
Iran	11.1	11.8	18.9	22.7	55.4	139.9
Japan	19.9	16.1	15.8	23.0	35.4	40.3
Mexico	135.3	143.0	157.1	217.3	298.0	360.1
South Africa	25.9	26.7	22.6	34.2	43.9	51.6
United Kingdom	42.2	40.9	46.8	57.8	74.9	69.5
Venezuela	44.3	50.2	59.3	61.1	105.5	126.1
West Germany	30.5	33.9	42.8	54.6	53.7	52.8
All Other Countries	291.2	295.3	330.6	397.5	586.8	676.8
Grand Total All countries exc. Canada	731.0	722.0	796.7	1013.7	1471.8	1731.6

Source: Bureau of the Census

Table 10-5

Total United States Exports of Automotive Parts and Components (excluding Canada) by Schedule B Number, 1970-1975

(millions of dollars)

Sch. B. No.		1970	1971	1972	1973	1974	1975
629-4005	V-type belts	.9	.8	.9	1.5	4.0	3.6
663-8202	Clutch facing	1.2	.9	.8	.6	.8	.8
663-8215	Brake lining	1.8	1.9	1.5	1.7	2.4	1.9
664-7020	Toughened glass	2.5	4.0	3.8	4.6	4.6	5.4
664-7040	Laminated glass	5.2	3.7	3.6	2.8	4.0	5.0
664-8015	Mirrors	.5	.6	.4	.5	.8	.7
698-1115	Locks and sets	.6	.5	.5	.9	.7	.8
698-6120	Springs, leaves	.9	.8	1.0	1.2	1.8	1.2
711-5002	Diesel engines, OEM assembly	8.5	6.3	10.8	16.9	21.9	28.7
711-5004	Diesel engines, replacement	10.3	8.4	8.3	7.2	11.2	26.3
711-5034	Gas engines, OEM	2.9	3.0	1.7	3.4	7.2	3.2
711-5036	Gas engines, replacement	5.8	6.4	6.7	4.3	7.4	8.5
711-5062	Parts n.e.c. OEM engine	22.9	21.0	20.1	41.4	55.1	56.1
711-5064	Parts n.e.c. engine, replacement	45.0	45.7	47.4	57.9	86.1	97.3
719-1509	Air conditioners	3.8	3.9	5.3	6.2	10.0	5.2
719-3154	Lifts	.9	1.0	2.9	.8	.8	1.2
719-3174	Hydraulic jacks & pts.	3.3	2.7	3.6	6.2	5.2	7.8
719-3176	Jacks and parts, n.e.c.	1.8	1.8	2.0	2.0	3.5	4.8
719-5320	Lubricating equip.	8.5	7.0	7.3	9.9	10.9	11.8
719-7010	Ball bearings, annular	14.5	12.9	13.1	17.0	25.6	30.4
719-7020	Ball bearings, complete n.e.c.	10.0	9.4	9.9	12.3	14.4	15.3
719-7024	Balls for bearings	.8	.9	.3	.8	1.2	.8
719-7026	Parts n.e.c. ball bearings	1.6	1.3	1.3	1.8	3.3	1.7
719-7030	Roller bearings, cyl.	8.6	7.4	8.6	9.5	12.5	14.7
719-7040	Roller bearings, sph.	1.4	2.2	1.6	1.6	2.3	2.6
719-7050	Roller bearings, taper	31.0	25.4	24.9	38.3	57.1	60.2
719-7060	Roller bearings, n.e.c.	4.5	4.2	4.8	5.9	8.1	9.0
719-7070	Rollers for bearings	2.2	2.0	2.3	3.3	4.2	3.5
719-7075	Parts n.e.c. roller bearings	3.3	3.8	3.2	3.9	5.3	6.8
722-2091	Switches, vehicle & aircraft 1/	5.0	5.1	5.3	6.6	8.1	8.3
723-1030	Ignition cables	1.2	4.4	5.3	5.1	7.1	4.4
724-2030	Radios exc. two-way	.8	.6	1.1	1.2	1.4	2.6
729-1210	Batteries	2.8	1.8	2.5	2.7	5.5	4.8
729-1240	Battery boxes	.6	.6	.8	.7	1.4	.8
729-1255	Parts, n.e.c. batteries	4.2	4.0	4.8	5.0	8.6	5.9
729-4110	Starter Motors	2.4	1.7	2.5	4.0	5.5	1.6
729-4120	Spark plugs	11.9	12.5	14.3	15.9	25.2	19.1
729-4135	Generators, alters.	3.3	3.4	5.0	8.2	9.6	11.4
729-4145	Coils, distributors, etc.	9.3	7.1	8.3	10.1	16.2	17.3
729-4150	Parts n.e.c. starting & ignition	20.8	19.4	20.4	24.9	32.6	30.3
729-4210	Sealed beam lamps	3.9	3.8	5.4	6.3	7.8	9.1
729-4220	Lighting equip. n.e.c.	2.4	2.4	2.8	3.3	6.2	6.0
729-4230	Horns, wipers, defrosters	1.5	1.7	1.3	2.2	2.8	3.9
732-8100	Truck, bus & car bodies	5.0	7.5	7.8	10.4	12.7	15.9
732-8910	Stampings	15.7	12.6	13.7	14.0	16.0	15.5
732-8932	Wheels	1.8	1.0	1.6	.9	1.9	2.4
732-8936	Brakes & parts	8.3	5.7	8.5	12.3	14.8	20.9
732-8938	Parts for assembly	159.9	176.8	198.9	277.0	384.2	442.1
732-8942	Exhaust equip., replacement	1.5	1.4	1.2	1.8	1.5	1.7
732-8943	Shock absorbers & parts, repl.	5.6	4.6	4.3	6.0	7.0	6.0
732-8944	Brakes & parts, repl.	8.6	8.7	10.1	11.3	14.2	16.8
732-8948	Parts n.e.c. for replacement	217.9	214.3	236.8	273.7	415.1	493.7
732-8950	Parts, used	3.5	3.3	3.3	5.0	6.7	8.0
733-3042	Truck trailers exc. off h'way 2/	14.0	14.4	15.8	19.8	33.3	93.9
733-3044	Parts n.e.c. for above 2/					15.8	29.7
733-3045	Off-highway trailers & pts.	.8	1.7	4.2	2.4	9.6	10.8
733-3060	Car trailers & parts	.4	.3	.4	.4	.4	.7
733-3090	Vehicles and parts n.e.c.	4.3	3.7	4.1	5.8	10.0	11.6
733-4000	Invalid carriages, motorized	--	--	--	.1	.2	.2
861-8220	Speedometers, etc.	.8	.9	.9	1.2	2.0	1.4
861-9320	Instruments etc. for maintenance	3.2	3.4	4.6	5.8	7.6	8.6
861-9742	Engine instruments for meas.	1.3	1.1	1.4	2.0	4.5	2.9
861-9748	Engine instruments exc. for meas.	.4	.3	.3	.3	.5	.7
861-9905	Pts. etc. for maint. equip.	1.9	1.4	1.6	1.4	1.3	1.0
861-9950	Pts. & acc. n.e.c. for instru.	.9	.8	.7	1.2	2.2	1.2

1/ Prior to 1973, Code 722-2091 was listed as Code 722-2054

2/ Prior to 1974, Codes 733-3042 and 733-3044 were combined in Code 733-3040.

-- Negligible amount.

Source: Bureau of Census.

Table 10-6

United States Imports of Motor Vehicles, Parts and Components (excluding Canada), 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	1923.9	2742.9	3116.9	3725.6	4462.8	4331.9
Trucks, Buses and Special Purpose Vehicles	63.0	133.5	277.6	339.5	544.8	387.7
Total Vehicles	1986.9	2876.4	3394.5	4065.1	5007.6	4719.6
Parts and Components	324.1	431.0	569.9	784.2	1049.4	924.1
Total Vehicles, Parts & Components	2311.0	3307.4	3964.4	4849.3	6057.0	5643.5

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

Source: Bureau of Census.

Table 10-7

United States Imports of Motor Vehicles, Automotive Parts and Components from Japan, 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	457.3	928.8	1138.5	1244.2	1685.4	1762.5
Trucks, Buses and Special Purpose Vehicles	37.9	104.8	249.2	298.3	483.2	346.3
Total Vehicles	495.2	1033.6	1387.7	1542.5	2168.6	2108.8
Parts and Components	135.2	156.3	225.2	290.2	370.5	327.3
Total Vehicles, Parts & Components	630.4	1189.9	1612.9	1832.7	2539.1	2436.1

1/ Free Alongside Ship (FAS) values are used for comparability between imports and exports values. Customs values were used in prior years because FAS values for imports were not available.

Columns may not add up to totals shown below because of rounding.

Source: Bureau of Census

Table 10-8

United States Imports of Motor Vehicles, Automotive Parts and Components from West Germany, 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	1065.5	1279.4	1417.5	1808.5	1876.3	1568.1
Trucks, Buses and Special Purpose Vehicles	9.1	10.2	9.1	4.1	9.6	4.3
Total Vehicles	1074.6	1289.6	1426.6	1812.6	1885.9	1572.4
Parts and Components	116.2	157.4	179.8	261.7	327.7	203.1
Total Vehicles, Parts & Components	1190.8	1447.0	1606.4	2074.3	2213.6	1775.5

1/ Free Alongside Ship (FAS) values are used for comparability between imports and exports values. Customs values were used in prior years because FAS values for imports were not available.

Columns may not add up to totals shown below because of rounding.

Source: Bureau of Census

Table 10-9

United States Imports of Motor Vehicles, Automotive Parts and Components from Italy, 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	64.3	83.4	129.3	123.4	240.6	300.7
Trucks, Buses and Special Purpose Vehicles	.4	.1	-	.7	.4	2.4
Total Vehicles	64.7	83.5	129.4	124.1	241.0	303.1
Parts and Components	5.9	6.0	8.4	11.4	18.7	22.9
Total Vehicles, Parts & Components	70.6	89.5	137.8	135.5	259.7	326.0

1/ Free Alongside Ship (FAS) values are used for comparability between imports and exports values. Customs values were used in prior years because FAS values for imports were not available.

Columns may not add up to totals shown below because of rounding.

\- Represents zero or negligible value.

Source: Bureau of Census

Table 10-10

United States Imports of Motor Vehicles, Automotive Parts and Components from Sweden, 1970-1975

(millions of dollars)

	1970	1971	1972	1973	1974	1975 1/
Passenger Cars	107.8	135.0	166.3	189.9	227.5	238.3
Trucks, Buses and Special Purpose Vehicles	.3	.3	.1	.3	.4	2.3
Total Vehicles	108.1	135.3	166.4	190.2	227.9	240.6
Parts and Components	4.4	4.8	6.9	11.3	15.9	14.8
Total Vehicles, Parts & Components	112.5	140.1	173.3	201.5	243.8	255.4

1/ Free Alongside Ship (FAS) values are used for comparability between imports and exports values. Customs values were used in prior years because FAS values for imports were not available.

Columns may not add up to totals shown below because of rounding.

Source: Bureau of Census

Table 10-11

United States Imports of Automotive Parts and Components from Selected Countries and the World (excludes Canada) 1970-1975

Country of Origin	1970	1971	1972	1973	1974	1975 1/
Australia	.8	.7	.7	.8	.8	.6
Brazil	.8	2.3	5.3	22.6	61.6	61.9
France	5.3	7.7	8.4	19.0	60.2	46.4
Italy	5.9	6.0	8.4	11.4	18.7	22.9
Japan	135.2	156.3	225.2	290.2	370.5	327.3
Mexico	11.4	20.4	27.3	45.5	72.7	122.0
Spain	1.0	1.6	8.5	16.3	15.7	11.5
Sweden	4.4	4.8	6.9	11.3	15.9	14.8
United Kingdom	33.3	62.9	86.1	77.0	58.9	61.8
West Germany	116.2	157.4	179.8	261.7	327.7	203.1
Grand Total: All Countries except Canada	324.1	431.0	569.9	784.2	1049.4	924.1

1/ Free Alongside Ship (FAS) values are used for comparability between import and export value. Custom values were used in prior years because FAS values of imports were not available.

Source: Bureau of Census

Table 10-12

United States Imports of Automotive Parts and Components (excluding Canada) 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	4.1	4.4	7.3	8.5	7.2	4.9
544-4120	Laminated glass 2/	5.8	7.3	10.0	8.4	9.5	7.2
544-4140	Other laminated glass 2/				3.6	4.3	2.6
647-0100	Hinges, fittings	2.3	2.8	4.8	6.6	8.4	9.0
652-8400	Springs and leaves	2.8	5.6	11.1	14.4	18.3	17.2
660-4430	Piston engines, inc. diesel	28.1	57.1	77.5	101.2	106.6	56.1
660-5000	Cast iron engine parts	.9	1.4	2.4	4.2	7.1	12.1
678-5027	Tape players, cartridge 3/	60.2	50.9	69.6	102.3	65.2	33.4
678-5029	Tape players, cassette 3/						12.9
680-7000	Repair kits	4.0	5.0	4.8	5.5	6.9	7.4
683-1000	Batteries and parts	4.8	5.5	6.5	10.0	15.0	11.8
683-6020	Generators	3.4	4.4	5.5	5.2	6.4	4.9
683-6040	Starters	5.6	6.3	8.6	11.5	13.8	9.8
683-6060	Spark plugs	8.9	11.6	15.4	17.0	24.2	17.5
683-6080	Ignition equipment	13.4	17.5	26.2	31.7	59.7	52.6
683-6500	Lighting equipment	7.0	8.2	10.8	14.6	18.6	17.7
685-2322	Radio receivers, a.m. 4/	20.5	27.1	28.8	63.1	79.5	182.7 5/
685-2326	Radio receivers exc. a.m. 4/						
686-2200	Voltage regulators	2.1	2.6	4.2	4.9	6.8	4.2
686-6000	Sealed beam lamps	.7	.5	.4	.6	1.1	.9
688-1200	Ignition wiring sets	.5	1.3	3.0	5.3	11.5	14.8
692-2400	Cast iron parts not adv.	.7	1.7	2.3	5.9	13.7	7.1
692-2710	Body stampings	8.8	12.9	18.0	26.7	27.1	30.6
692-2720	Bumpers	7.0	7.8	10.4	15.0	17.4	13.1
692-2730	Wheels	8.4	11.2	14.6	18.5	21.9	21.9
692-2740	Hubcaps, wheel covers	1.1	1.0	1.6	2.8	2.8	2.6
692-2750	Radiators	.6	1.0	1.7	1.6	2.1	3.0
692-2760	Mufflers, tail pipes	11.2	13.6	17.5	27.5	33.7	34.6
692-2770	Parts n.e.c.	104.7	154.5	193.9	252.2	359.0	314.6
711-9000	Taximeters, parts	--	.2	.2	.2	.3	.2
711-9820	Speedometers, tachs. & pts.	4.0	5.7	8.8	10.0	13.3	10.3
727-0600	Furniture and parts	1.0	1.7	4.0	5.0	6.0	5.5

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

5/ Includes imports of stereo, cartridges and cassette type radios not separately listed.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-13

United States Imports of Automotive Parts and Components
from Brazil, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	--	--	--	--	--	--
544-4120	Laminated glass 2/	--	--	--	--	--	--
544-4140	Other laminated glass 2/	--	--	--	--	--	--
647-0100	Hinges, fittings	--	--	--	--	--	--
652-8400	Springs and leaves	--	--	--	--	.1	--
660-4430	Piston engines, inc. diesel	--	--	--	--	--	--
660-5000	Cast iron engine parts	--	--	--	--	1.3	1.3
678-5027	Tape players, cartridge 3/	--	--	--	--	--	--
678-5029	Tape players, cassette 3/	--	--	--	--	--	--
680-7000	Repair kits	--	--	--	--	.1	--
683-1000	Batteries and parts	--	--	--	--	--	--
683-6020	Generators	.4	.3	.4	--	--	--
683-6040	Starters	--	--	--	--	.2	.1
683-6060	Spark plugs	--	--	.1	.3	--	--
683-6080	Ignition equipment	--	--	.2	.5	12.2	15.8
683-6500	Lighting equipment	--	--	--	.2	.2	--
685-2322	Radio receivers, a.m. 4/	--	--				18.0
685-2326	Radio receivers exc. a.m. 4/	--	--	.8	15.8	36.8	18.6
686-2200	Voltage regulators	--	--	--	--	--	--
686-6000	Sealed beam lamps	--	--	--	--	--	--
688-1200	Ignition wiring sets	--	--	--	.3	.2	.3
692-2400	Cast iron parts not adv.	--	--	--	--	.3	--
692-2710	Body stampings	--	--	--	--	--	--
692-2720	Bumpers	--	.1	.4	.6	1.1	.5
692-2730	Wheels	.1	.5	.5	.5	1.1	.7
692-2740	Hubcaps, wheel covers	--	--	--	--	.1	--
692-2750	Radiators	--	--	--	--	--	--
692-2760	Mufflers, tail pipes	--	--	.1	.3	.2	.1
692-2770	Parts n.e.c.	.1	1.2	2.5	3.9	7.2	6.1
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	--	--	--	--	--	--
727-0600	Furniture and parts	--	--	--	--	--	--

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-14

United States Imports of Automotive Parts and Components from France, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	--	--	.1	--	--	--
544-4120	Laminated glass 2/	--	--	--	--	--	--
544-4140	Other laminated glass 2/	--	--	--	.2	.3	.5
647-0100	Hinges, fittings	--	--	--	--	--	--
652-8400	Springs and leaves	.2	.5	.4	.9	.6	.6
660-4430	Piston engines, inc. diesel	--	.1	.1	--	.3	1.2
660-5000	Cast iron engine parts	.2	.3	.2	.4	.5	1.9
678-5027	Tape players, cartridge 3/	--	--	--	--	--	--
678-5029	Tape players, cassette 3/	--	--	--	--	--	--
680-7000	Repair kits	--	--	.1	.2	.2	.4
683-1000	Batteries and parts	--	--	--	--	--	.1
683-6020	Generators	--	--	--	.2	.2	.2
683-6040	Starters	--	.1	.1	.2	.2	.2
683-6060	Spark plugs	.3	.2	.3	.4	.4	.5
683-6080	Ignition equipment	.2	.2	.3	.4	.6	.6
683-6500	Lighting equipment	.3	.2	.4	.6	.9	1.7
685-2322	Radio receivers, a.m. 4/	--	--	--	--	--	--
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--	--	--
686-2200	Voltage regulators	--	--	--	.2	.1	.1
686-6000	Sealed beam lamps	.1	--	--	--	--	--
688-1200	Ignition wiring sets	--	--	--	--	.3	.3
692-2400	Cast iron parts not adv.	.6	1.4	1.9	3.0	5.6	2.4
692-2710	Body stampings	.2	.3	.2	.2	.1	.2
692-2720	Bumpers	.2	.2	.3	.1	.2	.2
692-2730	Wheels	--	--	--	.1	.2	.3
692-2740	Hubcaps, wheel covers	--	--	--	--	--	--
692-2750	Radiators	--	--	--	--	--	--
692-2760	Mufflers, tail pipes	.1	.1	.2	.3	.3	.3
692-2770	Parts n.e.c.	2.3	3.3	2.9	10.7	48.3	33.8
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	--	--	--	--	.1	.1
727-0600	Furniture and parts	.2	.3	.4	.5	.4	.4

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-15

United States Imports of Automotive Parts and Components from Italy, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	--	--	.2	.2	.2	.4
544-4120	Laminated glass 2/	--	--	.1	.1	.2	.2
544-4140	Other laminated glass 2/				--	.1	.3
647-0100	Hinges, fittings	.1	--	.2	.2	.3	.7
652-8400	Springs and leaves	--	--	--	--	--	--
660-4430	Piston engines, inc. diesel	--	.2	.1	.1	--	.2
660-5000	Cast iron engine parts	--	--	--	--	--	--
678-5027	Tape players, cartridge 3/	--	--	--	--	--	--
678-5029	Tape players, cassette 3/	--	--	--	--	--	--
680-7000	Repair kits	.2	.2	--	.1	.1	.2
683-1000	Batteries and parts	--	--	--	--	--	--
683-6020	Generators	.1	--	--	--	--	--
683-6040	Starters	--	--	.2	.1	.4	.2
683-6060	Spark plugs	--	--	--	--	--	--
683-6080	Ignition equipment	.2	.4	.4	.5	.8	1.7
683-6500	Lighting equipment	.2	.2	.3	.3	.8	1.0
685-2322	Radio receivers, a.m. 4/	--	--	--	--	--	--
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--	--	--
686-2200	Voltage regulators	--	--	--	.4	.9	.1
686-6000	Sealed beam lamps	--	--	--	--	--	--
688-1200	Ignition wiring sets	--	--	--	--	--	--
692-2400	Cast iron parts not adv.	--	--	--	--	--	--
692-2710	Body stampings	.5	.6	.8	1.1	.7	1.2
692-2720	Bumpers	.2	.1	.2	.2	.3	.3
692-2730	Wheels	.1	.2	.3	.5	.9	.7
692-2740	Hubcaps, wheel covers	--	--	--	--	--	--
692-2750	Radiators	--	--	--	--	--	.2
692-2760	Mufflers, tail pipes	.6	.5	.6	1.0	2.2	2.7
692-2770	Parts n.e.c.	2.9	2.8	4.1	5.6	9.3	11.7
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	.3	.3	.5	.6	.6	.6
727-0600	Furniture and parts	--	--	--	.1	.2	.1

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-16

United States Imports of Automotive Parts and Components from Japan, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	1.5	1.6	2.8	2.0	1.3	.8
544-4120	Laminated glass 2/	.9	1.2	2.9	1.9	1.8	1.4
544-4140	Other laminated glass 2/				1.0	.9	.6
647-0100	Hinges, fittings	.4	.7	1.3	1.3	1.7	2.1
652-8400	Springs and leaves	2.2	3.7	7.8	8.3	8.4	3.0
660-4430	Piston engines, inc. diesel	.4	.6	1.5	.3	.6	.7
660-5000	Cast iron engine parts	--	.1	.5	.3	--	.1
678-5027	Tape players, cartridge 3/	59.3	50.5	69.1	96.1	39.8	30.4
678-5029	Tape players, cassette 3/					19.0	11.8
680-7000	Repair kits	.6	.9	1.3	1.8	1.7	2.0
683-1000	Batteries and parts	3.3	4.1	4.4	5.6	11.7	8.5
683-6020	Generators	.2	.5	.7	.7	.9	1.7
683-6040	Starters	2.0	2.3	4.0	5.8	5.1	4.9
683-6060	Spark plugs	3.0	5.0	6.5	7.2	12.4	7.8
683-6080	Ignition equipment	6.5	7.8	13.0	15.0	20.9	16.7
683-6500	Lighting equipment	2.6	3.4	5.2	5.3		7.2
685-2322	Radio receivers, a.m. 4/	16.7	22.8	24.7	40.1	34.9	128.3 5/
685-2326	Radio receivers exc. a.m. 4/						
686-2200	Voltage regulators	.3	.5	.8	.8	1.1	1.1
686-6000	Sealed beam lamps	.5	.3	.2	.4	.8	.7
688-1200	Ignition wiring sets	.1	.1	.3	1.0	1.8	.7
692-2400	Cast iron parts not adv.	--	--	--	--	--	--
692-2710	Body stampings	1.9	3.2	5.7	8.0	10.1	12.1
692-2720	Bumpers	1.5	1.7	3.0	3.5	6.8	4.5
692-2730	Wheels	4.9	5.1	6.6	6.2	5.3	4.2
692-2740	Hubcaps, wheel covers	.6	.6	.9	1.5	1.3	1.0
692-2750	Radiators	.4	.5	1.1	.8	1.2	1.0
692-2760	Mufflers, tail pipes	.8	1.2	2.8	3.7	5.6	6.7
692-2770	Parts n.e.c.	22.3	33.9	51.9	64.5	82.1	60.7
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	1.9	2.9	5.6	5.9	7.7	5.9
727-0600	Furniture and parts	.4	.5	.7	1.1	1.5	1.0

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

5/ Includes imports of stereo, cartridges and cassette type radios not separately listed.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-17

United States Imports of Automotive Parts and Components from Mexico, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	--	--	--	--	--	--
544-4120	Laminated glass 2/	--	.8	.8	1.1	1.7	.8
544-4140	Other laminated glass 2/				--	.2	--
647-0100	Hinges, fittings	--	--	--	--	--	--
652-8400	Springs and leaves	--	.2	1.4	3.3	5.8	11.5
660-4430	Piston engines, inc. diesel	1.9	.9	1.8	5.7	6.9	27.1
660-5000	Cast iron engine parts	.2	.5	1.0	1.8	1.9	1.8
678-5027	Tape players, cartridge 3/	.3	--	--	--	--	--
678-5029	Tape players, cassette 3/		--	--	--	--	--
680-7000	Repair kits	--	--	--	--	--	--
683-1000	Batteries and parts	.1	.3	.2	.9	.6	.4
683-6020	Generators	--	--	--	--	--	--
683-6040	Starters	--	--	--	--	--	--
683-6060	Spark plugs	--	--	--	--	--	--
683-6080	Ignition equipment	--	--	--	1.2	4.5	2.1
683-6500	Lighting equipment	--	--	--	--	--	.1
685-2322	Radio receivers, a.m. 4/	--	--	--	--	--	--
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--	--	--
686-2200	Voltage regulators	.1	.2	.9	.3	.8	1.1
686-6000	Sealed beam lamps	--	--	--	--	--	--
688-1200	Ignition wiring sets	--	.6	1.8	3.0	5.1	8.3
692-2400	Cast iron parts not adv.	--	--	--	--	--	--
692-2710	Body stampings	.6	2.2	2.2	2.6	2.1	1.7
692-2720	Bumpers	--	--	--	--	--	--
692-2730	Wheels	1.6	3.2	4.9	8.6	8.5	11.4
692-2740	Hubcaps, wheel covers	--	--	--	--	--	--
692-2750	Radiators	--	--	--	--	.5	.9
692-2760	Mufflers, tail pipes	.5	1.5	2.2	2.9	3.1	3.6
692-2770	Parts n.e.c.	5.4	9.1	9.2	13.2	29.2	50.6
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	.6	.7	.7	.6	1.5	.3
727-0600	Furniture and parts	--	--	--	--	.2	--

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

\- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-18

United States Imports of Automotive Parts and Components
from Sweden, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	.2	.2	.1	.2	.2	.1
544-4120	Laminated glass 2/	--	--	.1	--	--	--
544-4140	Other laminated glass 2/	--	--		--	--	--
647-0100	Hinges, fittings	.1	--	.3	.4	.4	.3
652-8400	Springs and leaves	--	--	--	--	--	--
660-4430	Piston engines, inc. diesel	.3	.3	.3	--	.2	.1
660-5000	Cast iron engine parts	--	--	--	--	--	--
678-5027	Tape players, cartridge 3/	--	--	--	--	--	--
678-5029	Tape players, cassette 3/	--	--	--	--	--	--
680-7000	Repair kits	--	--	--	--	.1	.1
683-1000	Batteries and parts	--	--	--	--	--	--
683-6020	Generators	--	--	--	--	--	--
683-6040	Starters	--	--	--	--	--	--
683-6060	Spark plugs	--	--	--	--	--	--
683-6080	Ignition equipment	--	--	--	.1	.2	.3
683-6500	Lighting equipment	--	--	--	--	--	--
685-2322	Radio receivers, a.m. 4/	--	--	--	--	.1	--
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--		.1
686-2200	Voltage regulators	--	--	--	--	--	--
686-6000	Sealed beam lamps	--	--	--	--	--	--
688-1200	Ignition wiring sets	--	--	--	--	--	--
692-2400	Cast iron parts not adv.	--	--	--	1.1	3.3	2.6
692-2710	Body stampings	.2	.4	.8	1.1	1.3	1.2
692-2720	Bumpers	--	.2	.4	.3	.4	.3
692-2730	Wheels	--	--	.1	--	.1	--
692-2740	Hubcaps, wheel covers	--	--	--	--	.2	.2
692-2750	Radiators	--	--	.1	--	--	--
692-2760	Mufflers, tail pipes	.7	.8	1.1	2.2	2.6	3.2
692-2770	Parts n.e.c.	2.2	2.3	3.0	5.0	6.1	5.4
711-9000	Taximeters, parts	--	.1	--	--	.1	--
711-9820	Speedometers, tachs. & pts.	--	--	--	--	--	--
727-0600	Furniture and parts	--	--	--	--	.4	.3

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

-- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-19

United States Imports of Automotive Parts and Components
from United Kingdom, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	.4	.3	.5	1.1	.8	.5
544-4120	Laminated glass 2/	.3	.3	.4	.2	.2	.1
544-4140	Other laminated glass 2/				.2	.4	.2
647-0100	Hinges, fittings	.2	--	.2	.2	.2	.8
652-8400	Springs and leaves	--	.1	.4	--	1.5	1.2
660-4430	Piston engines, inc. diesel	5.0	24.5	39.7	34.2	1.0	.6
660-5000	Cast iron engine parts	--	--	.2	.2	.2	1.1
678-5027	Tape players, cartridge 3/	--	--	--	.3	.5	.2
678-5029	Tape players, cassette 3/	--	--	--		.2	--
680-7000	Repair kits	.5	.4	.5	.4	.6	.8
683-1000	Batteries and parts	.5	.5	.6	1.0	1.0	.9
683-6020	Generators	.8	.7	1.1	1.2	1.6	.8
683-6040	Starters	1.1	1.0	1.6	2.3	2.8	2.4
683-6060	Spark plugs	.8	.8	1.5	.8	.7	1.3
683-6080	Ignition equipment	1.0	1.4	1.7	1.4	2.3	2.2
683-6500	Lighting equipment	.6	.6	.8	1.0	.9	.8
685-2322	Radio receivers, a.m. 4/	--	--	--	--	--	--
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--	--	--
686-2200	Voltage regulators	.3	.3	.4	.5	.6	.5
686-6000	Sealed beam lamps	--	--	--	--	--	--
688-1200	Ignition wiring sets	--	--	.1	.1	.2	.2
692-2400	Cast iron parts not adv.	.1	.1	--	.1	.2	.4
692-2710	Body stampings	.8	1.3	.7	.6	.7	2.8
692-2720	Bumpers	.3	.5	.4	.2	.2	1.0
692-2730	Wheels	.5	.7	.8	.6	3.3	2.6
692-2740	Hubcaps, wheel covers	--	--	--	--	--	--
692-2750	Radiators	--	--	--	--	--	--
692-2760	Mufflers, tail pipes	1.1	.8	1.1	1.8	2.2	2.1
692-2770	Parts n.e.c.	17.7	27.4	31.6	27.1	34.6	36.6
711-9000	Taximeters, parts	--	--	--	--	--	--
711-9820	Speedometers, tachs. & pts.	.2	.4	.3	.3	.3	.3
727-0600	Furniture and parts	--	.4	1.2	1.1	1.3	1.1

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

\- Represents zero or negligible value.

Source: Bureau of Census.

Table 10-20

United States Imports of Automotive Parts and Components
from West Germany, 1970-1975 by TSUSA Number

(Millions of dollars)

TSUSA No.	Commodity	1970	1971	1972	1973	1974	1975 1/
544-3100	Toughened glass	.5	.6	.6	1.3	1.3	1.6
544-4120	Laminated glass 2/	4.0	4.4	4.4	3.8	3.4	2.6
544-4140	Other laminated glass 2/				.9	.5	.1
647-0100	Hinges, fittings	1.5	1.6	2.6	4.2	5.1	4.2
652-8400	Springs and leaves	.1	.2	--	.1	.2	.2
660-4430	Piston engines, inc. diesel	19.6	30.1	33.5	60.7	97.1	26.0
660-5000	Cast iron engine parts	.4	.5	.5	1.5	3.1	5.8
678-5027	Tape players, cartridge 3/	--	--	.2	.3	--	--
678-5029	Tape players, cassette 3/					.3	.5
680-7000	Repair kits	2.5	3.2	2.6	2.7	3.8	3.5
683-1000	Batteries and parts	.7	.6	1.1	2.2	1.2	1.4
683-6020	Generators	1.8	2.9	3.2	3.0	3.4	2.0
683-6040	Starters	1.9	2.7	2.6	3.0	5.0	1.7
683-6060	Spark plugs	4.7	5.3	6.8	8.1	10.2	7.7
683-6080	Ignition equipment	4.8	7.2	9.6	11.6	15.6	9.3
683-6500	Lighting equipment	3.2	3.7	3.8	6.6	7.2	5.8
685-2322	Radio receivers, a.m. 4/	1.8	1.9	2.3	2.2	2.9	.2
685-2326	Radio receivers exc. a.m. 4/	--	--	--	--	--	1.2
686-2200	Voltage regulators	1.3	1.5	2.0	2.8	2.9	1.3
686-6000	Sealed beam lamps	--	--	--	--	.1	.1
688-1200	Ignition wiring sets	.3	.5	.6	.8	1.1	1.0
692-2400	Cast iron parts not adv.	--	--	--	1.4	2.7	.6
692-2710	Body stampings	4.4	4.9	7.4	12.8	11.7	11.0
692-2720	Bumpers	4.7	4.6	5.7	9.5	8.1	5.8
692-2730	Wheels	1.0	1.2	1.3	1.9	2.2	1.7
692-2740	Hubcaps, wheel covers	.4	.3	.5	.8	.7	.6
692-2750	Radiators	.1	.3	.4	.5	.6	.5
692-2760	Mufflers, tail pipes	6.4	7.1	8.0	13.6	14.0	13.3
692-2770	Parts n.e.c.	48.6	70.6	77.2	102.0	118.9	89.0
711-9000	Taximeters, parts	--	--	.1	.1	.2	--
711-9820	Speedometers, tachs. & pts.	.6	1.1	1.1	1.9	2.4	2.4
727-0600	Furniture and parts	.2	.4	1.5	1.7	1.6	1.9

1/ Free Alongside Ship (FAS) values are used for comparability between import and export values. Customs values were used in prior years because FAS values of imports were not available.

2/ Prior to January 1, 1973, 544-4120 and 544-4140 were combined as 544-4100.

3/ Codes 678-5027 and 678-5029 were established on January 1, 1974 from code 678-5028. Code 678-5028 was transferred from 678-5025 on January 1, 1973.

4/ Codes 685-2322 and 685-2326 were established on January 1, 1975 from code 685-2320.

-- Represents zero or negligible value.

Source: Bureau of Census.

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